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SOME STUDIES ON RING B FORMING REACTIONS[1]

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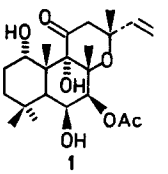
Abstract - Cyclization of the unsaturated sulfoxides 18b,18c under Pummerer conditions provided the six-membered products 20a and 21a, whereas base-catalyzed cyclization of the stereoisomeric epoxysulfones 16a,16b and 17a,17b led exclusively to the five-membered compounds 12a,12b and 15a,15b. The reaction 18b,18c -> 20a,21a has been used to prepare the trans-decaline derivative 24 starting from the dimethylcyclohexenone 6.

Forskolin (1), a labdane diterpene isolated from the Indian herb Coleus forskohlii Briq. (Labiatae) has been reported to be a unique adenylate cyclase activator, to lower normal or elevated blood pressure, to have a positive inotropic effect on the heart muscle, and to cause marked inhibition of platelet activation.[2] Synthetic work on this highly challenging target [3-5] has uncovered very elegant solutions for the construction of the decalin part of the molecule relying on

a) different types of intramolecular cycloaddition reactions, [3,9-13]
b) a radical cyclization in tandem with an intramolecular Mukaiyama reaction, [14]
c) a tandem Michael-aldol sequence, [15]
d) an anionic Cope rearrangement.[16]



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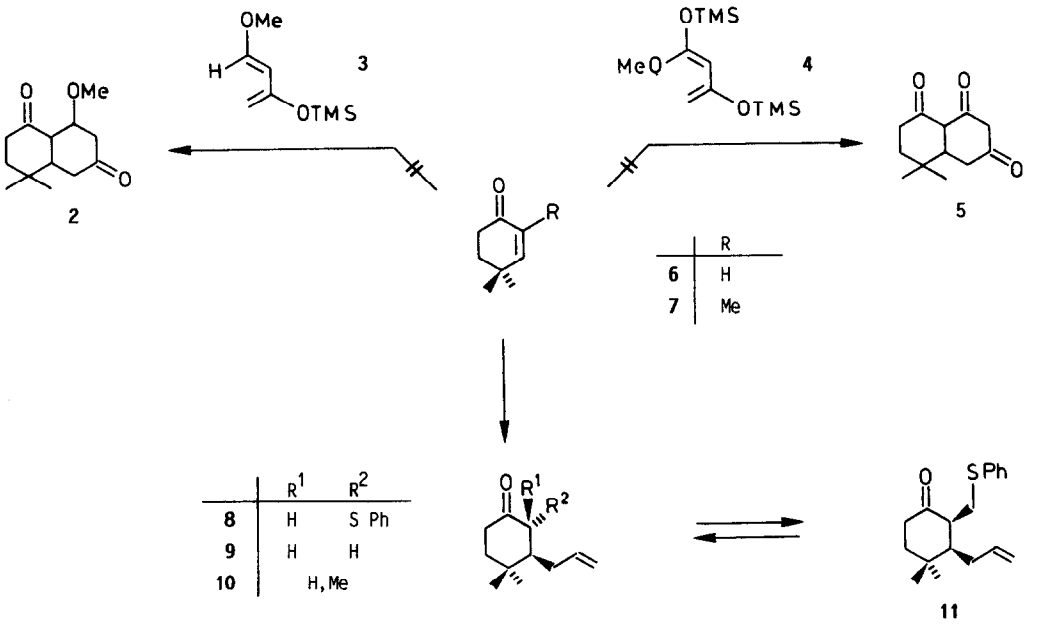
Intermolecular Diels-Alder approaches proved less fruitful.[17-19] In our hands all attempts to add either of the electron-rich dienes 3[20] or 4[21] to the sterically hindered enone 6 (Scheme 1) were completely unsuccessful.[19] Related observations have been reported by Snider[17] and by Sih.[18]

In the sequel we describe results obtained on attempted annulation of ring B onto 6 and 7 in a stepwise manner.

$TiCl_4$-catalyzed reaction of 6 with allyltrimethylsilane [22] led to the desired 1,4-addition product which could be trapped with chloromethyl phenyl sulfide [23] to furnish the trans addition product 8 (58% yield) together with 9 (9%). Under acidic conditions a 2:1 equilibrium mixture of 8 and 11 was established. The relative configuration of 8 and 11 follows from the cyclization reactions that are detailed below. The Sakurai reaction [22] of the trimethyl compound 7 with allyltrimethylsilane also proceeded as desired but in this case we were unable to trap the intermediate enolate with chloromethyl phenyl sulfide and a number of other elec-

trophiles. The simple addition product 10 was obtained in all cases investigated.[19]

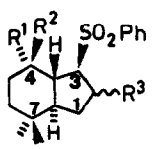


Scheme 1.

As starting materials for the cyclization studies the stereoisomeric epoxy sulfones 16a, 16b, 17a, and 17b as well as the stereoisomeric unsaturated sulfoxides 18b, 18c, 19b, and 19c were prepared from 8 and 11, respectively, using straightforward chemistry (see Scheme 2 and Experimental).

Cyclization of the epoxy sulfones [24-26] can, in principle, occur in two different modes, leading to five- or six-membered rings. According to Baldwin's rules [27] one would expect the exo-mode to prevail, leading to five-membered cyclization products. On the other hand, in some related cases with stabilized carbanions, six-membered ring formation has been observed when the epoxide end farther from the carbanionic centre was less substituted than the nearer one.[25,28-30] Recently, Benedetti et al.[31] published results on the base-catalyzed cyclization of ω-epoxy-1,1-bis-sulfones. They found in a case which is closely related to our systems that the five- and six-membered cyclization products are formed in a 6:1 ratio.

In our case, reaction of each of the stereoisomeric epoxy sulfones 16a, 16b, 17a, and 17b with LDA resulted in the formation of a single five-membered cyclization product (12a, 12b, 15a, 15b). The relative configuration of these stereoisomeric compounds was determined after O-methylation and acetal cleavage to give 12c, 12d, 15c, and 15d, respectively. The ^{1}H NMR results collected in Table 1 (see also partial structures 12c,d A and 15c,d A) clearly show the strong deshielding effects of the sulfonyl group on the protons at C-7a and C-10 if they are on the same side of the cyclopentane ring. The cis- and trans-fusion, respectively, of the two rings was inferred from the coupling constant $J_{3a,7a}$. The cis-relation of 2-H and 7a-H in 15d was independently confirmed by NOE results summarized in partial formula 15d B. In agreement with these stereochemical assignments sulfinate elimination from 12c and 15c led to 13 whereas from 12d and 15d the isomeric



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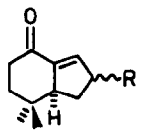
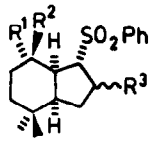


	R
13	α - CH_2OMe
14	β - CH_2OMe



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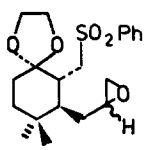
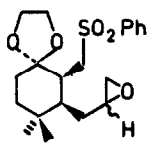
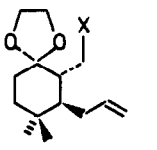
12, 15	R^1, R^2	R^3
a	$O(CH_2)_2O$	α - CH_2OH
b	$O(CH_2)_2O$	β - CH_2OH
c	O	α - CH_2OMe
d	O	β - CH_2OMe



16a, 16b

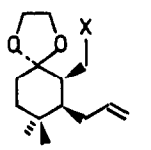


17a, 17b

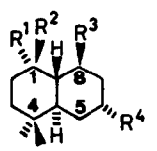


18	X
a	SPh
b, c	SOPh

8 11



19	X
a	SPh
b, c	SOPh



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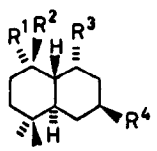

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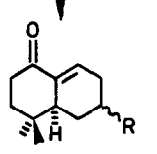
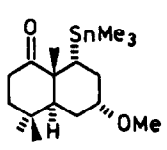
20, 21	R^1, R^2	R^3	R^4
a	$O(CH_2)_2O$	SPh	$OCOCF_3$
b	$O(CH_2)_2O$	SPh	OH
c	$O(CH_2)_2O$	SO_2Ph	OH
d	O	SPh	OMe



	R
22	α - OMe
23	β - OMe



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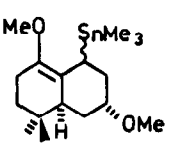

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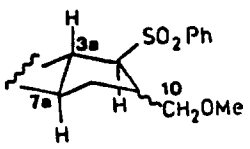
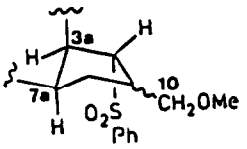
Scheme 2.

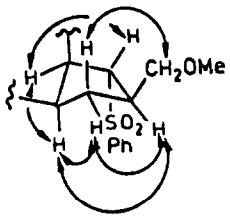
elimination product 14 was obtained.



12c, d A



15c, d A

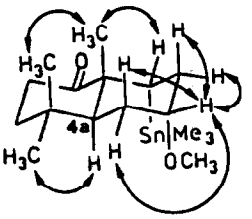


15 d B

Tab 1. Selected ^1H NMR data of 12c, 12d, 15c, 15d.

	δ-values		$J_{3a,7a}$ (Hz)
	7a-H	CH_2-10	
12c	1.64-1.75	3.02 - 3.12	12.5
12d	1.41-1.55	3.87 and 4.15	12.5
15c	2.70-2.77	3.59 and 3.88	8.5
15d	2.29-2.36	2.98-3.00	7.5

Cyclization to give a six-membered ring B was achieved under Pummerer reaction conditions [32] starting from a mixture of the stereoisomeric sulfoxides 18b,18c. Heating of 18b,18c in the presence of trifluoroacetic anhydride afforded 20a and 21a which could not be separated. The mixture was, therefore, hydrolyzed to provide a 55:14 mixture of 20b and 21b which was readily separated chromatographically. MCPBA oxidation converted 20b into the hydroxy sulfone 20c. From the mixture of the unsaturated sulfoxides 18a,18b the stereoisomeric hydroxy sulfones 20c and 21c were prepared directly in 56% and 21% yield, respectively, by the sequence (i) treatment with trifluoroacetic anhydride, (ii) ester hydrolysis, and (iii) oxidation with MCPBA. The relative configuration at C-4a, C-8 and C-8a in 20c and 21c and hence in 20b and 21b was deduced from the following coupling constants: $J_{4a,8a}$ about 12 Hz in 20c and in 21c corresponding to a trans-decaline system in both cases, and $J_{8,8a}$ = 8 Hz for 20c (trans relation of both protons) and $J_{8,8a}$ = 3 Hz for 21c (cis-relation of the two protons). The configuration at C-6 follows from results described below.- 20b was then converted into 22 by (i) OH group methylation, (ii) acetal cleavage, and (iii) oxidation of the sulfide function with one equivalent of MCPBA to give the corresponding sulfoxides, (iv) benzenesulfinate elimination. Using the same reaction sequence 21b was converted into 23 showing that both series of compounds differ in their configuration at C-6. Finally, reaction of 22 with trimethylstannyllithium,[33] followed by enolate trapping with methyl iodide provided the trans-decaline derivate 24 in 61% yield along with the O-alkylation product 25 (14%). In the NMR spectra of 24 each ^1H and ^{13}C resonance, respectively, has been assigned applying two-dimensional (2D) $^1H/^1H$ chemical shift correlation spectroscopy (COSY [34]), heteronuclear $^{13}C/^1H$ 2D shift correlation using large ($^1J_{CH}$) C,H couplings,[35] and $^1H/^1H$ nuclear Overhauser enhancement (NOE) difference spectroscopy.[36] The relative configuration followed straightforwardly from the NOE results, the most indicative of which are summarized in formula 24A. Most specifically, the cis-relation between the OCH_3 group and the proton at C-4a was clearly established.[37]



24 A

EXPERIMENTAL

General.
All O_2 - or moisture-sensitive reactions were performed in oven-dried glassware under a positive pressure of argon. Sensitive liquids were transferred by syringe and were introduced into the reaction flasks through rubber septa. Usual work-up means partitioning the reaction mixture between water and an appropriate organic solvent, drying the combined organic layers with $MgSO_4$ and removal of the solvent by distillation in vacuum using a rotatory evaporator. The intrumentation used was: ^1H NMR: WP 80 (Bruker), AM 400 (Bruker); ^{13}C-NMR: AM 400 (Bruker); IR: Perkin Elmer 1310; MS: MAT-731 and MAT-CH-5 (Finnigan). LC: Liquid chromatography (LC) was performed using SiO_2 (63-100 µm, Macherey & Nagel); for medium pressure chromatography (MPLC) 25 cm x 3 cm (column A, 100 g SiO_2), 55 cm x 3 cm (column B, 170 g SiO_2) or 35 cm x 4 cm (column C, 200 g SiO_2) glass tubes, SiO_2 (40-63 µm, Merck), a Duramat pump (CfG); and the UV detector RCT-Thomachrom (Reichelt) were used.

Reaction of 4,4-dimethyl-cyclohex-2-enone (6) with allyltrimethylsilane and chloromethyl phenyl sulfide.
To a solution of 6[38] (100 mg, 0.81 mmol) and $TiCl_4$ (100 µl, 0.91 mmol) in CH_2Cl_2 (3 ml) at -78°C allyltrimethylsilane (150 µl, 0.95 mmol) was added. After stirring at -78°C for 15h chloromethyl phenyl sulfide (255 µl, 1.9 mmol) was added. The mixture was stirred at -10 to -5°C for 11h. Usual work-up and LC (hexanes - ether 100:1) gave 8 (134 mg, 58%) and 9 (12 mg, 9%) as colourless oils.

(±)-3t-Allyl-4,4-dimethyl-2r-phenylsulfanylmethyl-cyclohexanone (8).
^1H NMR (80 MHz, $CDCl_3$): δ = 1.05 (s, 6H; CH_3), 3.15-3.30 (m, 2H; -CH_2-S-), 4.88-5.06 (m, 3H; vinylic H's), 7.10-7.40 (m, 5H; Ar-H's).- IR (CCl_4): 3045, 3040 (=CH), 1715 (C=O), 1640, 1585 cm^{-1} (C=C).- MS: m/z (%) = 288 (44, M^+), 179 (29), 165 (51), 123 (100). (Found: C, 74.83; H, 8.44. $C_{18}H_{24}OS$ (288.5) requires C, 74.95; H, 8.39).

(±)-3-Allyl-4,4-dimethyl-cyclohexanone (9).
^1H NMR (80 MHz, $CDCl_3$): δ = 1.00 (s, 3H; CH_3), 1.05 (s, 3H; CH_3), 4.80-5.90 (m, 3H; vinylic H's).- IR (CCl_4): 3070 (=CH), 1710 (C=O), 1635 cm^{-1} (C=C).- MS: 166.1359 (4, M^+, Calc for $C_{11}H_{18}O$: 166.1358), 125 (30), 110 (9), 107 (6), 97 (17), 55 (100).

(±)-3r-Allyl-2 ,4,4-trimethyl-cyclohexanone (10).
To a stirred aqueous solution of 2,4,4-trimethyl-cyclohex-2-enone (7)[39] (23.8 g, 0.17 mol) and $TiCl_4$ (22 ml, 0.2 mol) in CH_2Cl_2 (450 ml) at -78°C a solution of allyltrimethylsilane (35 ml, 0.22 mol) in CH_2Cl_2 (50 ml) was added. After 12h at -78°C saturated aq. $NaHCO_3$ (400 ml) was added. The mixture was allowed to warm to 20°C and was then worked up as usual. Fractional distillation gave 10 (25.3 g) and a residue of 2.8 g, which on LC (hexanes - ethyl acetate 80:1) furnished a second crop of 10 (0.8 g, combined yield 84%) as a colourless oil.- B.p.: 77-79°C/26 Pa.- ^1H NMR (80 MHz, C_6D_6): δ = 0.80 (s, 6H; CH_3) 1.14 (d, J = 6.0 Hz, >CH-CH_3), 4.80-6.00 (m, 3H; vinylic H's).- IR (CCl_4): 3100 (=CH), 1720 cm^{-1} (C=O).- MS: m/z (%) = 180.1514 (5, M^+, Calc for $C_{12}H_{20}O$: 180.1514), 165 (1), 139 (62), 124 (14), 121 (11), 111 (18), 97 (100).

(±)-3c-Allyl-4,4-dimethyl-2r-phenylsulfanylmethyl-cyclohexanone (11).
A solution of 8 (400 mg, 1.4 mmol) in acetone (20 ml) and 2N HCl (2 ml) was refluxed for 66h. After cooling to 20°C ether (20 ml) and saturated aq. $NaHCO_3$ (15 ml) were added. Usual work-up and MPLC (column C, hexanes - ethyl acetate 100:1) gave 11 (131 mg, 33%) as a colourless oil and recovered 8 (255 mg, 64%).- ^1H NMR (80 MHz, $CDCl_3$): δ = 1.02 (s, 3H; CH_3), 1.18 (s, 3H; CH_3), 4.85-6.02 (m, 3H; vinylic H's), 7.12-7.35 (m, 5H; Ar-H's).- IR (CCl_4): 3070 (=CH), 1710 cm^{-1} (C=O).- MS: m/z (%) = 288.1548 (80, M^+, Calc for $C_{18}H_{24}OS$: 288.1548), 179 (44), 178 (40), 123 (92), 110 (90), 55 (100), 41 (99).

(±)-3t-Allyl-4,4-dimethyl-2r-phenylsulfanylmethyl-cyclohexanone ethane-1,2-diyl acetal (18a).
A solution of 8 (900 mg, 2.65 mmol), p-TsOH (25 mg, 0.15 mmol) and 1,2-ethanediol (0.3 ml, 5.4 mmol) in $CHCl_3$ (40 ml) was refluxed for 3h using a soxhlet apparatus (CaH_2 as water trap). After cooling to 20°C saturated $NaHCO_3$ (15 ml) was added. Usual work-up and LC (hexanes - ethyl acetate 50:1) provided 18a (888 mg, 87%).- M.p. 76-77°C (from hexane).- ^1H NMR (80 MHz, $CDCl_3$): δ = 0.88 (s, 3H; CH_3), 0.97 (s, 3H; CH_3), 2.80-3.35 (m, 2H; $-CH_2-S-$), 3.78-4.23 (m, 4H; $(O-CH_2)_2$), 4.75-6.14 (m, 3H, vinylic H's), 7.02-7.42 (m, 5H; Ar-H's).- IR (CCl_4): 3080, 3070 (=CH), 1680, 1640, 1580 cm^{-1} (C=C).- MS: m/z (%) = 332.1813 (1.6, M^+, Calc for $C_{20}H_{28}O_2S$: 332.1810), 287 (3), 223 (63), 161 (53), 99 (100).

(±)-3c-Allyl-4,4-dimethyl-2r-phenylsulfanylmethyl-cyclohexanone ethane-1,2-diyl acetal (19a).
19a was prepard as described for 18a. MPLC (hexanes - ethyl acetate 15:1) furnished pure 19a (17%) and a 9:1 mixture of 19a and 18a (71%).- ^1H NMR (80 MHz, $CDCl_3$): δ = 0.89 (s, 3H; CH_3), 0.91 (s, 3H; CH_3), 2.87 and 3.24 (AB part of an ABX-system, J_{AX} = 7 Hz, J_{BX} = 5.5 Hz, $|J_{AB}|$ = 12 Hz, 2H; $-CH_2-S-$), 3.80-4.00 (m, 4H; $(O-CH_2)_2$), 4.84-5.07 (m, 3H; vinylic H's), 7.08-7.43 (m, 5H; Ar-H's).- IR (CCl_4): 3080 (=CH), 1680, 1640 and 1585 cm^{-1} (C=C).- MS: m/z (%) = 332.1810 (0.1, M^+, Calc for $C_{20}H_{28}O_2S$: 332.1810), 223 (1), 178 (3), 84 (100).

Reaction of 18a and 19a with MCPBA (1 equiv).
To a solution of a 1:9 mixture of 18a and 19a (107 mg, 0.32 mmol) in CH_2Cl_2 (5ml) at -10°C a suspension of MCPBA (85%, 66.5 mg, 0.32 mmol) in CH_2Cl_2 (15 ml) was added. The mixture was allowed to warm to 20°C (15 min) and 10% aq. Na_2CO_3 (20 ml) was added. Usual work-up and MPLC (column B, hexanes - ethyl acetate - NEt_3 1:1:0.1) gave four isomers; 19b (62 mg, 55%), 19c (34 mg, 30%), 18b (6.5 mg, 6%) and 18c (4 mg, 4%). Only 18b was crystalline while the others were colourless sirups. Pure 18a was oxidized with MCPBA to give 18b (59%) and 18c (36%).

(±)-(2*R*)-3t-Allyl-2r-[(*R*)-benzenesulfinylmethyl]-4,4-dimethyl-cyclohexanone ethane-1,2-diyl acetal (18b).
M.p. 139-140°C (from hexane - ethanol).- ^1H NMR (80 MHz, $CDCl_3$): δ = 0.90 (s, 3H; CH_3), 0.94 (s, 3H; CH_3), 2.00-3.10 (m, 4H; allylic H's and $-CH_2-SO-$), 4.00 (s, $W_{1/2}$ = 2 Hz, 4H; $(O-CH_2)_2$), 4.74-5.98 (m, 3H; vinylic H's), 7.40-7.70 (m, 5H; Ar-H's).- IR (CCl_4): 3070 (=CH), 1635 (C=C), 1045 cm^{-1} (>SO).- MS: m/z (%) = 348.1761 (1.7, M^+, calc for $C_{20}H_{28}O_3S$: 348.1759), 331 (6), 305 (5), 223 (58), 99 (100).

(±)-(2*R*)-3t-Allyl-2r-[(*S*)-benzenesulfinylmethyl]-4,4-dimethyl-cyclohexanone ethane-1,2-diyl acetal (18c).
^1H NMR (80 MHz, $CDCl_3$): δ = 0.64 (s, 3H; CH_3), 0.88 (s, 3H; CH_3), 2.81 and 3.18 (AB part of an ABX-system, J_{AX} = 8.5 Hz, J_{BX} = 2.5 Hz, $|J_{AB}|$ = 13 Hz, 2H; $-CH_2-SO-$), 3.92-4.12 (m, 4H; $(O-CH_2)_2$), 4.77-5.82 (m, 3H; vinylic H's), 7.41-7.80 (m, 5H; Ar-H's).- IR (CCl_4): 3060 (=CH), 1040 cm^{-1} (>SO).- MS: m/z (%) = 348.1767 (1.6, M^+, Calc for $C_{20}H_{28}O_3S$: 348.1759), 331 (5), 305 (4), 223 (48), 99 (100).

(±)-(2*R*)-3c-Allyl-2r-[(*R*)-benzenesulfinylmethyl]-4,4-dimethyl-cyclohexanone ethane-1,2-diyl acetal (19b).
^1H NMR (80 MHz, $CDCl_3$): δ = 0.76 (s, 3H; CH_3), 0.96 (s, 3H; CH_3), 1.20-2.95 (complex of m's, containing $-CH_2-SO-$), 3.98 (s, $W_{1/2}$ = 2 Hz, 4H; $(O-CH_2)_2$), 4.96-6.16 (m, 3H; vinylic H's), 7.45-7.75 (m, 5H; Ar-H's).- IR (CCl_4): 3080 (=CH), 1050 cm^{-1} (>SO).- MS: m/z (%) = 348.1761 (2, M^+, Calc for $C_{20}H_{28}O_3S$: 348.1759), 331 (7), 305 (5), 223 (66), 99 (100).

(±)-(2*R*)-3c-Allyl-2r-[(*S*)-benzenesulfinylmethyl]-4,4-dimethyl-cyclohexanone ethane 1,2-diyl acetal (19c).
^1H NMR (80 MHz, $CDCl_3$): δ = 0.85 (s, 3H; CH_3), 0.91 (s, 3H; CH_3), 3.66 and 4.17 (AB part of an ABX-system, J_{AX} = J_{BX} = 6 Hz, $|J_{AB}|$ = 12 Hz, 2H; $-CH_2-SO-$), 3.83-4.17 (m, 4H; $(O-CH_2)_2$), 4.79-5.91 (m, 3H; vinylic H's), 7.45-7.77 (m, 5H; Ar-H's).- IR (CCl_4): 3070 and 3080 (=CH), 1050 cm^{-1} (>SO), (small band at 1745 cm^{-1}).- MS: m/z (%) = 348.1764 (1, M^+, Calc for $C_{20}H_{28}O_3S$: 348.1759), 331 (5), 305 (6), 223 (61), 99 (100).

16a and 16b from 18a
To a solution of 18a (500 mg, 1.5 mmol) in CH_2Cl_2 (40 ml) at 0°C a suspension of MCPBA (85%, 1050 mg, 5.2 mmol) in CH_2Cl_2 (10 ml) was added. The mixture was then stirred at 20°C for 12h. Addition of saturated $NaHCO_3$ (50 ml), work-up and MPLC (column B, hexanes - ethyl acetate 5:1) furnished a mixture of 16a and 16b and small samples of pure 16a and 16b (combined yield: 561 mg, 92%).

(±)-(2*S*)-2r-Benzenesulfonylmethyl-3t-[(*R*)-2,3-epoxy-propyl]-4,4-dimethyl-cyclohexanone ethane-1,2-diyl acetal (16a).
M.p. 109-110°C (from CCl_4).- ^1H NMR (80 MHz, $CDCl_3$): δ = 0.89 (s, 3H; CH_3), 0.98 (s, 3H; CH_3), 3.22 and 3.46 (AB part of an ABX-system, J_{AX} = J_{BX} = 2.8 Hz, $|J_{AB}|$ = 14 Hz, 2H; $-CH_2-SO_2-$), 3.66-3.91 (m, 4H; $(O-CH_2)_2$), 7.39-7.94 (m, 5H; Ar-H's).- IR (CCl_4): 3050 (=CH), 1150 and 1305 cm^{-1} (>SO_2).- MS: m/z (%) = 239 (100, ($M-SO_2Ph$)$^+$), 99 (97), 84 (48), 55 (36), 41 (37). (Found: C, 63.10; H, 7.48. $C_{20}H_{28}O_5S$

(380.5) requires C, 63.13; H, 7.42).

(±)-(2Ξ)-2r-Benzenesulfonylmethyl-3t-[(Ξ)-2,3-epoxy-propyl]-4,4-dimethyl-cyclohexanone ethane-1,2-diyl acetal (16b).
M.p. 104°C (from CCl_4).- ^1H NMR (80 MHz, $CDCl_3$): δ = 0.84 (s, 3H; CH_3), 0.89 (s, 3H; CH_3), 3.13-3.90 (m, 6H; $(O-CH_2)_2$ and $-CH_2-SO_2-$), 7.31-7.90 (m, 5H; Ar-H's).- IR (CCl_4): 3060 (=CH), 1150 and 1305 cm^{-1} (>SO_2).- MS: m/z (%) = 239 (100, $(M-SO_2Ph)^+$), 99 (81), 55 (23), 41 (21). (Found: C, 63.15; H, 7.52. $C_{20}H_{28}O_5S$ (380.5) requires C, 63.13; H, 7.42).

17a and 17b from 19b and 19c.
As described above a mixture of 19b and 19c was oxidized with MCPBA to give after MPLC (hexanes-ethyl acetate 10:1) crystalline 17a (45%) and 17b (47%, colourless oil).

(±)-(2Ξ)-2r-Benzenesulfonylmethyl-3c-[(Ξ)-2,3-epoxy-propyl]-4,4-dimethyl-cyclohexanone ethane-1,2-diyl acetal (17a).
M.p. 145-146°C (from hexane ethanol).- ^1H NMR (80 MHz, $CDCl_3$): δ = 0.91 (s, 3H; CH_3), 1.00 (s, 3H; CH_3), 3.77 (narrow m, $W_{1/2}$ = 8 Hz, 4H; $(O-CH_2)_2$), 7.41-8.00 (m, 5H; Ar-H's).- IR (KBr): 3050 and 3060 (=CH), 1145, 1280 and 1295 cm^{-1} (>SO_2).- MS: m/z (%) = 239 (100, $(M-SO_2Ph)^+$), 99 (82), 69 (21), 55 (27), 41 (25). (Found: C, 62.86; H, 7.40. $C_{20}H_{28}O_5S$ (380.5) requires C, 63.13; H, 7.42).

(±)-(2Ξ)-2r-Benzenesulfonylmethyl-3c-[(Ξ)-2,3-epoxy-propyl]-4,4-dimethyl-cyclo-hexanone ethane-1,2-diyl acetal (17b).
^1H NMR (80 MHz, $CDCl_3$): δ = 0.87 (s, 3H; CH_3), 0.99 (s, 3H; CH_3), 3.24 ("d", J = 5 Hz, 2H; $-CH_2-SO_2-$), 3.78 (m, $W_{1/2}$ = 6 Hz, 4H; $(O-CH_2)_2$), 7.49-8.03 (m, 5H; Ar-H's).- IR (CCl_4): 3060 (=CH), 1145 and 1305 cm^{-1} (>SO_2).- MS: m/z (%) = 239.1648 (65, $(M-SO_2Ph)^+$, Calc for $C_{14}H_{23}O_3$: 239.1647), 141 (18), 139 (13), 99 (100), 55 (51), 41 (57).

Cyclization of 16a, 16b, 17a , and 17b with LDA.
A solution of LDA (0.32 mmol) in dry THF (2 ml) was cooled to -78°C and was then added at -78°C to a solution of 16a (50 mg, 0.13 mmol) in dry THF (3 ml). The mixture was stirred at -78°C for 1h and was then diluted with ether (2 ml) and water (3 ml). Usual work-up and MPLC (column A, hexanes - ethyl acetate 2:1) gave 12a (37.5 mg, 75%).
Using the same conditions 16b was converted into 12b (81%), 17a into 15a (84%), and 17b into 15b (74%).

(±)-3c-Benzenesulfonyl-2t-hydroxymethyl-7,7-dimethyl-(3ar,7at)-octahydro-inden-4-one ethane-1,2-diyl acetal (12a).
M.p. 188-189°C (from hexane - ethanol).- ^1H NMR (80 MHz, $CDCl_3$): δ = 0.83 (s, 3H; CH_3), 0.89 (s, 3H; CH_3), 3.37-3.89 (m, 7H; $(O-CH_2)_2$, >$CH-SO_2-$, $-CH_2-OH$), 7.40-8.00 (m, 5H; Ar-H's).- IR ($CHCl_3$): 3520 (OH), 3010 (=CH), 1145 and 1290 cm^{-1} (>SO_2).- MS: m/z (%) = 239 (100, $(M-SO_2Ph)^+$), 211 (5), 177 (5), 159 (9), 99 (33). (Found: C, 62.93; H, 7.44. $C_{20}H_{28}O_5S$ (380.5) requires C, 63.13; H, 7.42).

(±)-3c-Benzenesulfonyl-2c-hydroxymethyl-7,7-dimethyl-(3ar,7at)-octahydro-inden-4-one ethane-1,2-diyl acetal (12b).
M.p. 137-138°C (from hexane - ethanol).- ^1H NMR (80 MHz, $CDCl_3$): δ = 0.90 (s, 3H; CH_3), 0.92 (s, 3H; CH_3), 2.97-4.53 (m, 7H; $(O-CH_2)_2$, >$CH-SO_2-$, $-CH_2-OH$), 7.40-7.90 (m, 5H; Ar-H's).- IR (CCl_4): 3520 (OH), 3060 (=CH), 1135 and 1285 cm^{-1} (>SO_2).- MS: m/z (%) = 365 (0.7, $(M-CH_3)^+$), 316 (0.9), 298 (0.4), 239 (100), 99 (48). (Found: C, 63.10; H, 7.50. $C_{20}H_{28}O_5S$ (380.5) requires C, 63.13; H, 7.42).

(±)-3c-Benzenesulfonyl-2t-hydroxymethyl-7,7-dimethyl-(3ar,7ac)-octahydro-inden-4-one ethane-1,2-diyl acetal (15a).
M.p. 183-184°C (from hexane - ethanol).- ^1H NMR (80 MHz, $CDCl_3$): δ = 0.88 (s, 3H; CH_3), 0.98 (s, 3H; CH_3), 3.40-4.41 (m, 7H; $(O-CH_2)_2$, >$CH-SO_2-$, $-CH_2-OH$), 7.50-7.93 (m, 5H; Ar-H's).- IR (CCl_4): 3510 (OH), 3060 (=CH), 1145, 1285 and 1305 cm^{-1} (>SO_2).- MS: m/z (%) = 380 (0.7, M^+), 365 (0.7), 309 (0.6), 239 (64), 99 (100). (Found: C, 63.18; H, 7.40. $C_{20}H_{28}O_5S$ (380.5) requires C, 63.13; H, 7.42).

(±)-3c-Benzenesulfonyl-2c-hydroxymethyl-7,7-dimethyl-(3ar,7ac)-octahydro-inden-4-one ethane-1,2-diyl acetal (15b).
167-170°C (dec., from hexane - ethanol).- ^1H NMR (80 MHz, $CDCl_3$): δ = 0.87 (s, 3H; CH_3), 1.00 (s, 3H; CH_3), 3.36-4.38 (m, 7H; $(O-CH_2)_2$, >$CH-SO_2-$, $-CH_2-OH$), 7.45-7.98 (m, 5H; Ar-H's).- IR ($CHCl_3$): 3500 (OH), 1135 and 1285 cm^{-1} (>SO_2).- MS: m/z (%) = 365 (0.5, $(M-CH_3)^+$), 239 (82), 99 (100). (Found: C, 63.21; H, 7.46. $C_{20}H_{28}O_5S$ (380.5) requires C, 63.13; H, 7.42).

Reaction of 12a, 12b, 15a and 15b with KOH/MeI and treatment of the reaction products with acid.
a) To a solution of 12b (101 mg, 0.27 mmol) in DMSO (3 ml) solid KOH (30 mg, 0.53 mmol) was added. The mixture was stirred for 15 min at 20°C, and then MeI (50 µl, 0.80 mmol) was added. After stirring for 30 min, the mixture was diluted with CH_2Cl_2 (25 ml) and water (5 ml). The organic layer was evaporated, redissolved in acetone (10 ml) and 2N HCl (2 ml), and this mixture was refluxed for 15 h. After

cooling to 20°C usual work-up and MPLC (column B, hexanes - ethyl acetate 10:1) furnished 12d (81 mg, 87%, colourless crystals) alongside with 14 (5.5 mg, 10%, colourless oil).
Using the same procedure, 12a was converted into 12c (93%).
b) Using a slightly modified procedure 15b (15 mg, 39 mmol) was treated with solid KOH (10 mg, 0.18 mmol), MeI (20 µl, 0.32 mmol) in hexane (15 ml), followed by treatment with p-TsOH (3 mg, 16 µmol) in acetone (10 ml) and water (2 ml), to give after LC (hexanes - ethyl acetate 5:1) 15d (9.8 mg, 71%).
Using procedure b), 15a (100 mg, 0.26 mmol) was converted into 15c (50%, colourless crystals) and 13 (27%, colourless oil).

(±)-3c-Benzenesulfonyl-2t-methoxymethyl-7,7-dimethyl-(3ar,7at)-octahydro-inden-4-one (12c).
M.p. 145-146°C (from ethanol).- ^{1}H NMR (400 MHz, C_6D_6, COSY): δ = 0.60 (s, 3H; CH_3-9), 0.74 (s, 3H; CH_3-8), 1.00-1.18 (m, 2H; CH_2-6), 1.46-1.70 (m, 3H; CH_2-1, 7a-H), 1.88-1.94 (m, 2H; CH_2-5), 2.86 (s, 3H; OCH_3), 2.89-2.99 (m, 2H; CH_2-10), 3.01-3.08 (m, 1H; 2-H), 3.20 (m, $J_{3a,7a}$ = 12.5 Hz, $J_{3a,3}$ = 10.0 Hz, 1H; 3a-H), 4.00 (m, $J_{3,2}$ = 5.0 Hz, $J_{3,3a}$ = 10.0 Hz, 1H; 3-H), 6.96-7.04 (m, 3H; Ar-H's), 7.92-7.95 (m, 2H; Ar-H's).- ^{1}H NMR (400 MHz, $CDCl_3$, COSY): δ = 0.92 (s, 3H; CH_3-9), 1.06 (s, 3H; CH_3-8), 1.44-1.52 (m, 1H of CH_2-6), 1.64-1.75 (m, 4H; CH_2-1, 1H of CH_2-6, 7a-H), 2.06-2.13 (m, 1H of CH_2-5), 2.26-2.34 (m, 1H of CH_2-5), 2.88 (m, $W_{1/2}$ = 15 Hz, 1H; 2-H), 3.02-3.12 (m, 3H; H-3a, CH_2-10), 3.14 (s, 3H; OCH_3), 3.65 (m, $J_{3,2}$ = 5.0 Hz, $J_{3,3a}$ = 10.0 Hz, 1H; H-3), 7.47-7.61 (m, 3H; Ar-H's), 7.84-7.87 (m, 2H; Ar-H's).- ^{13}C NMR (100.6 MHz, $CDCl_3$, DEPT): δ = 18.0 (C-8), 28.9 (C-9), 30.1 (C-1), 33.2 (C-7), 37.8 (C-2), 38.7 (C-5), 42.8 (C-6), 52.7 (C-3a), 56.2 (C-7a), 58.6 (OCH_3), 63.0 (C-3), 75.1 (C-10), 128.6, 128.9, 133.6, 138.7 (Ar-C's), 206.4 (C-4).- IR ($CHCl_3$): 1720 (C=O), 1145 and 1300 cm^{-1} (>SO_2).- MS: m/z (%) = 350 (6, M^+), 335 (2), 305 (7), 254 (<1), 209 (55), 193 (10), 177 (24), 45 (100). (Found: C, 65.22; H, 7.45. $C_{19}H_{26}O_4S$ (350.5) requires C, 65.11; H, 7.48).

(±)-3c-Benzenesulfonyl-2c-methoxymethyl-7,7-dimethyl-(3ar,7at)-octahydro-inden-4-one (12d).
M.p. 136-137°C (from ethanol).- ^{1}H NMR (400 MHz, $CDCl_3$, COSY): δ = 0.97 (s, 3H; CH_3-9), 1.12 (s, 3H; CH_3-8), 1.41-1.55 (m, 3H; 1H of CH_2-1, 1H of CH_2-6, 7a-H), 1.66-1.72 (m, 1H of CH_2-6), 1.91-1.97 (m, 1H of CH_2-5), 2.05-2.14 (m, 1H of CH_2-5), 2.46-2.56 (m, 1H; 2-H), 3.03 (m, $J_{3a,7a}$ = 12.5 Hz, $J_{3a,3}$ = 8.0 Hz, 1H; 3a-H), 3.37 (s, 3H; OCH_3), 3.87 and 4.15 (AB part of an ABX-system, J_{AX} = 9 Hz, J_{BX} = 4.5 Hz, $|J_{AB}|$ = 10 Hz, 2H; CH_2-10), 4.05 (m, $J_{3,2}$ = 10.5 Hz, $J_{3,3a}$ = 8.0 Hz, 1H; 3-H), 7.47-7.60 (m, 3H; Ar-H's), 7.78-7.82 (m, 2H; Ar-H's).- ^{13}C NMR (100.6 MHz, $CDCl_3$, DEPT): δ = 18.4 (C-8), 29.1 (C-9), 33.2 (C-1 and C-7), 38.4 (C-5), 42.4 (C-6), 42.7 (C-2), 54.0 (C-3a), 56.7 (C-7a), 59.0 (OCH_3), 60.6 (C-3), 72.0 (C-10), 128.5, 128.9, 133.7, 138.9 (Ar-C's), 205.7 (C-4).- IR ($CHCl_3$): 3010 and 3040 (=CH), 1725 (C=O), 1150 and 1310 cm^{-1} (>SO_2).- MS: m/z (%) = 254 (4), 209 (82, $(M-SO_2Ph)^+$), 193 (10), 177 (21), 45 (100). (Found: C, 65.23; H, 7.47. $C_{19}H_{26}O_4S$ (350.5) requires C, 65.11; H, 7.48).

(±)-3c-Benzenesulfonyl-2c-methoxymethyl-7,7-dimethyl-(3ar,7ac)-octahydro-inden-4-one (15c).
M.p. 113-115°C (from ethanol).- ^{1}H NMR (400 MHz, $CDCl_3$, COSY): δ = 0.88 (s, 3H; CH_3-9), 1.17 (s, 3H; CH_3-8), 1.40-1.49 (m, 1H of CH_2-1), 1.56-1.73 (m, 2H; CH_2-6), 1.87-1.93 (m, 1H of CH_2-1), 2.12-2.19 (m, 1H of CH_2-5), 2.25-2.34 (m, 1H of CH_2-5), 2.60-2.69 (m, 1H; 2-H), 2.70-2.77 (m, 1H; 7a-H), 2.92 (m, $J_{3a,7a}$ = 8.5 Hz, $J_{3a,3}$ = 2.0 Hz, 1H; 3a-H), 3.24 (s, 3H; OCH_3), 3.59 and 3.88 (AB part of an ABX system, J_{AX} = 10.0 Hz, J_{BX} = 5.0 Hz, $|J_{AB}|$ = 9.5 Hz, 2H; CH_2-10), 4.45 (m, $J_{3,2}$ = 8.0 Hz, $J_{3,3a}$ = 2.0 Hz, 1H; 3-H), 7.49-7.60 (m, 3H; Ar-H's), 7.83-7.85 (m, 2H; Ar-H's).- ^{13}C NMR (100.6 MHz, $CDCl_3$, DEPT): δ = 26.8 (C-9), 28.4 (C-8), 30.0 (C-1), 31.5 (C-7), 34.7 (C-6), 36.9 (C-5), 40.2 (C-2), 50.5 (C-7a), 52.5 (C-3a), 58.6 (OCH_3), 64.3 (C-3), 71.4 (C-10), 127.9, 129.1, 133.5, 139.7 (Ar-C's), 208.6 (C-4).- IR (CCl_4): 3030 (=CH), 1715 (C=O), 1145 and 1305 cm^{-1} (>SO_2).- MS: m/z (%) = 350 (0.1, M^+), 305 (0.3), 254 (2), 209 (47), 193 (2), 177 (21), 45 (100).- (Found: C, 64.96; H, 7.50. $C_{19}H_{26}O_4S$ (350.5) requires C, 65.11; H, 7.48).

(±)-3c-Benzenesulfonyl-2t-methoxymethyl-7,7-dimethyl-(3ar,7ac)-octahydro-inden-4-one (15d).
M.p. 119-120°C (from hexane).- ^{1}H NMR (400 MHz, $CDCl_3$, COSY): δ = 0.91 (s, 3H; CH_3-9), 0.91-1.13 (m, 1H of CH_2-1), 1.26 (s, 3H; CH_3-8), 1.53-1.60 (m, 1H of CH_2-6), 1.70-1.79 (m, 1H of CH_2-6), 1.88-1.95 (m, 1H of CH_2-1), 2.20- 2.28 (m, 1H of CH_2-5), 2.29-2.36 (m, 1H; 7a-H), 2.43-2.51 (m, 1H of CH_2-5), 2.55-2.65 (m, 1H; 2-H), 2.98-3.00 (m, 2H; CH_2-10), 3.08 (s, 3H; OCH_3), 3.19 (m, $J_{3a,7a}$ = 7.5 Hz, 1H; 3a-H), 4.09 (m, $J_{3,2}$ = 1.5 Hz, $J_{3,3a}$ = 6.5 Hz, 1H; 3-H), 7.51-7.63 (m, 3H; Ar-H's), 7.88-7.90 (m, 2H; Ar-H's).- ^{13}C NMR (100.6 MHz, $CDCl_3$, DEPT): δ = 27.7 (C-8), 28.6 (C-9), 31.4 (C-1), 31.6 (C-7), 34.7 (C-6), 37.4 (C-5), 39.3 (C-2), 51.5 (C-3a), 53.6 (C-7a), 58.7 (OCH_3), 63.7 (C-3), 74.7 (C-10), 128.5, 129.1, 133.6, 138.2 (Ar-C's), 207.9 (C-4).- IR (CCl_4): 3060 (=CH), 1710 (C=O), 1145 and 1305 cm^{-1} (>SO_2).- MS: m/z (%) = 350 (3, M^+), 335 (1), 305 (2), 254 (1), 209 (48), 193 (5), 177 (21), 45 (100). (Found: C, 65.07; H, 7.59. $C_{19}H_{26}O_4S$ (350.5) requires C, 65.11; H, 7.48).

14 from 15d
To a solution of sodium methoxide, prepared from sodium (5 mg, 0.22 mmol) and dry methanol (5 ml), 15d (40 mg, 0.11 mmol) was added. The mixture was stirred for 30 min at 20°C. Work-up and LC (hexanes - ethyl acetate 10:1) gave 14 (20 mg, 85%).

(±)-2t-Methoxymethyl-7,7-dimethyl-(7ar)-1,2,5,6,7,7a-hexahydro-inden-4-one (14).
^{1}H NMR (80 MHz, $CDCl_3$): δ = 0.82 (s, 3H; CH_3), 0.99 (s, 3H; CH_3), 3.22-3.34 (complex of m's containing s at 3.33, 5H; $-CH_2-OCH_3$), 6.57 (X part of an ABX system, $J_{AX}+J_{BX}$ = 4 Hz, 1H; vinylic H).- IR (CCl_4): 1680 (C=O), 1615 cm^{-1} (C=C).- MS: m/z (%) = 208.1467 (10, M$^+$, Calc for $C_{13}H_{20}O_2$: 208.1463), 163 (27), 45 (100).

13 from 12c.
As described for 15d -> 14, 12c (50 mg, 0.14 mmol) was converted into 13 (15 mg, 51%), 18 mg (36%) of 12c were recovered.

(±)-2c-Methoxymethyl-7,7-dimethyl-(7ar)-1,2,5,6,7,7a-hexahydro-inden-4-one (13).
^{1}H NMR (80 MHz, $CDCl_3$): δ = 0.82 (s, 3H; CH_3), 0.99 (s, 3H; CH_3), 3.22-3.40 (complex of m's, containing s at 3.30, 5H; $-CH_2-OCH_3$), 6.52 (X part of an ABX system, $J_{AX}+J_{BX}$ = 4 Hz, 1H; vinylic H).- IR (CCl_4): 1680 (C=O), 1615 cm^{-1} (C=C).- MS: m/z (%) = 208.1463 (10, M$^+$, Calc for $C_{13}H_{20}O_2$: 208.1463), 163 (29), 45 (100).

(±)-4,4-Dimethyl-8 -phenylsulfanyl-6ξ-trifluoroacetoxy-(4ar,8at)-octahydro-naphthalen-1-one ethane-1,2-diyl acetal (20a,21a).
To a suspension of 18b and 18c (53 mg, 0.15 mmol) in hexane (4 ml) trifluoroacetic anhydride (135 µl, 0.96 mmol) was added at 20°C. A clear solution resulted which was stirred for 20 min. After addition of saturated aq. $NaHCO_3$ (4 ml), the mixture was worked-up as usual. MPLC (column B, hexanes - ethyl acetate 40:1) furnished a mixture of 20a and 21a (53.5 mg, 79%).- ^{1}H NMR (80 MHz, $CDCl_3$): δ = 0.89 (CH_3), 0.91 (2 CH_3) and 0.93 (CH_3), 2.99-4.29 (m, $(O-CH_2)_2$ and CH-S-), 4.52-5.10 and 5.10-5.27 (2m, >CH-CO_2CF_3 of 20a and 21a), 7.13-7.47 (m, Ar-H's).- IR (CCl_4): 3070 (=CH), 1780 cm^{-1} (C=O).- MS: m/z (%) = 429 (1, $(M-CH_3)^+$, 400 (1), 335 (98), 99 (100). (Found: C, 59.50; H, 6.26. $C_{22}H_{27}F_3O_4S$ (444.5) requires C, 59.45; H, 6.12).

20b and 21b from a mixture of 18b and 18c.
To a mixture of 18b and 18c (2.73 g, 7.8 mmol), dissolved in hexane (70 ml) and CCl_4 (30 ml), trifluoroacetic anhydride (13 ml, 92 mmol) was added at 20°C. The mixture was stirred for 30 min, then evaporated to dryness, and the residue was dissolved in hexane (50 ml). To this solution water (0.5 ml, 28 mmol) and solid potassum hydroxyde (560 mg, 10 mmol) were added. The mixture was refluxed for 15h, then cooled to 20°C, and water (15 ml) was added. Usual work-up and MPLC (two columns C were connected, hexanes - ethyl acetate 20:1) gave 20b (1.50 g, 55%, colourless sirup) and 21b (0.39 g, 14%, colourless crystals).

(±)6c-Hydroxy-4,4-dimethyl-8t-phenylsulfanyl-(4ar,8at)-octahydro-naphthalen-1-one ethane-1,2-diyl acetal (20b).
^{1}H NMR (80 MHz, $CDCl_3$): δ = 0.88 (s, 3H; CH_3), 0.92 (s, 3H; CH_3), 3.10-3.60 (m, 2H; >CH-S- and >CH-OH), 3.83-4.20 (m, 4H; $(O-CH_2)_2$), 7.11-7.47 (m, 5H; Ar-H's).- IR (CCl_4): 3620 and 3600-3200 (OH), 3070 cm^{-1} (=CH).- MS: m/z (%) = 348 (27, M$^+$), 239 (73), 159 (2), 99 (100). (Found: C, 69.00; H, 8.12. $C_{20}H_{28}O_3S$ (348.5) requires C, 68.93; H, 8.10).

(±)-6t-Hydroxy-4,4-dimethyl-8c-phenylsulfanyl-(4ar,8at)-octahydro-naphthalen-1-one ethane-1,2-diyl acetal (21b).
M.p. 130-131°C (from hexane).- ^{1}H NMR (80 MHz, $CDCl_3$): δ = 0.85 (s, 3H; CH_3), 0.91 (s, 3H; CH_3), 3.50-4.28 (m, 6H; $(O-CH_2)_2$, >CH-S- and >CH-OH), 7.10-7.46 (m, 5H; Ar-H's).- IR (CCl_4): 3630 and 3600-3300 (OH), 3070 (=CH), 1585 cm^{-1}. - MS: m/z (%) = 348.1760 (19, M$^+$, Calc for $C_{20}H_{28}O_3S$: 348.1759), 239 (64), 159 (20), 99 (100).

20c and 21c from 18c and 18b.
First 18c (80 mg, 0.23 mmol) was converted to a mixture of 20b and 21b as described above. Then sodium methoxide (15 mg, 0.26 mmol), dissolved in methanol (15 ml), was added and the mixture was stirred for 5h at 20°C. After work-up, the crude material was dissolved in CH_2Cl_2 (15 ml), and MCPBA (85%, 110 mg, 0.54 mmol) was added. After stirring at 20°C for 30 min, work-up and MPLC (column B, hexanes - ethyl acetate 2:1) provided 20c (49 mg, 56%) and 21c (18 mg, 21%) as colourless crystals. Using the same procedure, 18b was converted to 20c and 21c in 18% and 52% yield, respectively.

20c from 20b.
20b was converted to 20c as described for 18a -> 16a,16b (2 equiv. of MCPBA were used). LC (hexanes - ethyl acetate 2:1) furnished 20c in 85% yield.

(±)-8c-Benzenesulfonyl-6t-hydroxy-4,4-dimethyl-(4ar,8at)-octahydro-naphthalen-1-one ethane-1,2-diyl acetal (20c).
M.p. 157-158°C (from CCl_4).- ^{1}H NMR (400 MHz, DMSO-d_6, COSY): δ = 0.77 (s, 3H; CH_3-9), 0.87 (s, 3H; CH_3-10), 0.87-0.96 (m, 1H; 5-H), 1.23-1.43 (m, 5H; 1H of CH_2-2, CH_2-3, 4a-H and 1H of CH_2-7), 1.57-1.63 (m, 1H of CH_2-2), 1.80-1.95 (m, 2H; 1H of CH_2-5 and 1H of CH_2-7), 2.14 (dd, $J_{8a,4a}$ = 12.5 Hz, $J_{8a,8}$ = 8.0 Hz, 1H; 8a-H),

3.40-3.55 (m, 2H; 6-H and 8-H), 3.11-3.17, 3.55-3.61, 3.61-3.68, and 3.68-3.75 (4m, 4H; CH_2-1'and CH_2-2'), 4.53 (d, J = 5.0 Hz, 1H; OH), 7.57-7.82 (m, 5H; Ar-H's).- ^{13}C-NMR (100.6 MHz, DMSO-d_6, DEPT): δ = 18.8 (C-9), 29.9 (C-10), 29.9 and 37.4 (C-2, C-3), 32.6 (C-4), 33.8 (C-5), 35.0 (C-7) 42.2 (C-4a), 44.1 (C-8a), 59.9 (C-8), 62.9 and 63.5 (C-1', C-2'), 66.4 (C-6), 108.2 (C-1), 127.4, 128.9, 132.5, 141.8 (Ar-C's).- IR (KBr): 3480 (OH), 3060 (=CH), 1125 and 1295 cm^{-1} (>SO_2).- MS: m/z (%) = 365 (1, $(M-CH_3)^+$), 239 (100), 159 (15), 99 (60). (Found: C, 62.98; H, 7.40. $C_{20}H_{28}O_5S$ (380.5) requires C, 63.13; H, 7.42).

(±)-8t-Benzenesulfonyl-6c-hydroxy-4,4-dimethyl-(4ar,8at)-octahydro-naphthalen-1-one ethane-1,2-diyl acetal (21c).
M.p. 222°C (from ethanol).- ^{1}H NMR (400 MHz, DMSO-d_6, COSY): δ = 0.79 (s, 3H; CH_3-9), 0.86 (s, 3H; CH_3-10), 1.15-1.64 (m, 8H; CH_2-2, CH_2-3, 4a-H, CH_2-5, 1H of CH_2-7), 2.07 (dd, $J_{8a,4a}$ = 11.5 Hz, $J_{8a,8}$ = 3.0 Hz, 1H; 8a-H) 2.21-2.30 (m, 1H of CH_2-7), 3.30-3.33 (m, 1H; 8-H), 3.43-3.50, 3.57-3.64, 3.68-3.75, and 3.78-3.85 (4m, 4H; CH_2-1' and CH_2-2'), 4.05-4.13 (m, 1H; 6-H), 4.63 (d, J = 4.5 Hz, 1H; OH), 7.59-7.81 (m, 5H; Ar-H's).- ^{13}C NMR (100.6 MHz, DMSO-d_6, DEPT): δ = 18.2 (C-9), 28.3 (C-7), 29.4 (C-10), 30.2, 31.5 and 37.8 (C-2, C-3 and C-5), 31.9 (C-4), 38.8 (C-4a), 40.0 (C-8a), 58.2 (C-8), 62.1 (C-6), 63.5 and 66.0 (C-1', C-2'), 108.8 (C-1), 128.3, 129.0, 133.4, 138.8 (Ar-C's).- IR (KBr): 3490 (OH), 3050 (=CH), 1135, 1285 and 1295 cm^{-1} (SO_2).- MS: m/z (%) = 365 (1, $(M-CH_3)^+$), 239 (100), 159 (18), 99 (70). (Found: C, 63.19; H, 7.44. $C_{20}H_{28}O_5S$ (380.5) requires C, 63.13; H, 7.42).

(±)-6c-Methoxy-4,4-dimethyl-8t-phenylsulfanyl-(4ar,8at)-octahydro-naphthalen-1-one (20d).
To a solution of 20b (1.36 g, 3.9 mmol) in hexane (70 ml) solid KOH (330 mg, 5.8 mmol) was added, and the mixture was refluxed for 10 min (KOH dissolved slowly). After cooling to 20°C, MeI (0.37 ml, 5.9 mmol) and DMSO (20 µl) were added. The mixture was stirred at 20°C for 36h and then worked up as usual. The crude product was taken up in acetone (80 ml), and p-TsOH (10 mg, 58 µmol) dissolved in water (5 ml) was added. Refluxing for 15 h, followed by work-up and MPLC (column C, hexanes - ethyl acetate 10:1) provided 20d (915 mg, 74%).- ^{1}H NMR (80 MHz, $CDCl_3$): δ = 0.94 (s, 3H; CH_3), 1.09 (s, 3H; CH_3), 2.70-3.40 (complex of m's containig s at 3.28, 5H; >CH-S- and >C<u>H</u>-OCH_3), 7.21-7.59 (m, 5H; Ar-H's).- IR (CCl_4): 3060 (=CH), 1720 (C=O), 1585 cm^{-1}.- MS: m/z (%) = 318.1653 (1, M^+, Calc for $C_{19}H_{26}O_2S$: 318.1653), 195 (3), 86 (65), 84 (100).

(±)-6t-Methoxy-4,4-dimethyl-8c-phenylsulfanyl-(4ar,8at)-octahydro-naphthalen-1-one (21d).
21b was converted to 21d as described above. MPLC (hexanes - ethyl acetate 15:1) gave 21d in 71% yield.- ^{1}H NMR (80 MHz, $CDCl_3$): δ = 0.93 (s, 3H; CH_3), 1.09 (s, 3H; CH_3), 2.05-3.87 (complex of m's containing s at 3.18, 5H; >CH-S- and >C<u>H</u>-OCH_3), 7.18-7.57 (m, 5H; Ar-H's).- IR (CCl_4): 3060 (=CH), 1725 cm^{-1} (C=O).- MS: m/z (%) = 318.1653 (100, M^+, Calc for $C_{19}H_{26}O_2S$: 318.1653), 286 (18), 208 (25), 177 (54).

(±)-6c-Methoxy-4,4-dimethyl-(4ar)-3,4,4a,5,6,7-hexahydro-2H-naphthalen-1-one (22).
To a solution of 20d (915 mg, 2.9 mmol) in CH_2Cl_2 (150 ml) a suspension of MCPBA (85%, 584 mg, 2.9 mmol) in CH_2Cl_2 (30 ml) was added. The mixture was stirred at 20°C for 15 min, then the solvent was evaporated, the residue redissolved in toluene (30 ml) and NEt_3 (1.5 ml), and the solution was heated to 110°C for 30h in a sealed vessel. Cooling to 20°C, working up as usual and MPLC (column C, hexanes - ethyl acetate 10:1) furnished 22 (440 mg, 73%).- ^{1}H NMR (80MHz, $CDCl_3$): δ = 0.91 (s, 3H; CH_3), 1.08 (s, 3H; CH_3), 3.23-3.80 (complex of m's containing s at 3.30, 4H; >C<u>H</u>-OCH_3), 6.73-6.87 (m, 1H; vinylic H).- IR (CCl_4): 1695 (C=O), 1620 cm^{-1} (C=C).- MS: m/z (%) = 208.1469 (46, M^+, Calc for $C_{13}H_{20}O_2$: 208.1463), 193 (6), 177 (25), 176 (31), 150 (45), 135 (100), 120 (66), 107 (56).

(±)-6t-Methoxy-4,4-dimethyl-(4ar)-3,4,4a,5,6,7-hexahydro-2H-naphthalen-1-one (23).
As described for 22, 21d was converted to 23 in 61% yield.- ^{1}H NMR (80 MHz, $CDCl_3$): 0.79 (s, 3H; CH_3), 1.08 (s, 3H; CH_3), 3.35 (s, 3H; OCH_3), 3.61-3.79 (m, $W_{1/2}$ = 9 Hz, 1H; >C<u>H</u>-OCH_3), 6.75-6.90 (m, 1H; vinylic H).- IR (CCl_4): 1690 (C=O), 1620 cm^{-1} (C=C).- MS: m/z (%) = 208.1463 (12, M^+, Calc for $C_{13}H_{20}O_2$: 208.1463), 193 (3), 135 (24), 120 (40), 100 (60), 72 (100).

Reaction of 22 with trimethylstannyllithium and methyl iodide.
Trimethylstannyllithium was prepared from trimethyltin chloride (550 mg, 2.75 mmol) and lithium (50 mg, 7.25 mmol) in dry THF (5.5 ml) by the procedure of Soloski.[40] The dark green solution was cooled to -78°C and was then added to a cooled (-78°C) solution of 22 (290 mg, 1.4 mmol) in dry THF (3 ml). The mixture was stirred at -78°C for 15 min and then slowly warmed to -10°C. MeI (0.18 ml, 2.9 mmol) was added. Stirring at -10°C for 15 min, warming to 20°C, quenching with water (5 ml), usual work-up, and MPLC (column C, hexanes - ethyl acetate 20:1) furnished 25 (75 mg, 14%) and 24 (330 mg, 61%) as colourless oils.

(±)-6c-Methoxy-4,4-dimethyl-8c-trimethylstannyl-(4ar,8at)-octahydro-2H-naphthalen-1-one (24).
^{1}H NMR (400 MHz, $CDCl_3$, COSY): δ = 0.05 (s and 2d's, $J_{117Sn,1H}$ = 49 Hz, $J_{119Sn,1H}$ = 51 Hz, 9H; $Sn(CH_3)_3$), 0.93 (s, 3H; CH_3-10), 1.00 (s, 3H; CH_3-11), 1.29 (s, 3H; CH_3-9), 1.39-1.44 (m, 2H; 4a-H and 5β-H), 1.50 (dd, $J_{8,7}$ = 2.5 Hz, $J_{8,7'}$ = 5.0 Hz, 1H; 8-H), 1.55-1.65 (m, 1H; 3α-H), 1.72-1.83 (2m, 2H; 3β-H and 1H of CH_2-7), 1.88-1.94 (m, 1H; 5α-H), 2.08-2.13 (m, $J_{7,7'}$ = 13.5 Hz, 1H of CH_2-7), 2.15-2.21 (m, 1H; 2α-H), 2.72-2.82 (m, 1H; 2β-H), 2.91-3.00 (m 1H; 6-H), 3.34 (s, 3H; OCH_3).- ^{13}C NMR (100.6 MHz, $CDCl_3$, DEPT): δ = -7.5 ($Sn(CH_3)_3$, (also 2d, $J_{117Sn,13C}$ = 122 Hz, $J_{119Sn,13C}$ = 127 Hz)), 21.2 (C-11), 21.5 (C-10), 28.5 (C-7), 30.7 (C-5), 31.9 (C-9), 32.7 (C-4), 33.9 (C-4a), 35.0 (C-3), 40.5 (C-2), 49.6 (C-8), 51.5 (C-8a), 55.9 (OCH_3), 79.7 (C-6), 217.8 (C-1).- IR (CCl_4): 1700 cm^{-1} (C=O).- MS: m/z (%) = 373 (100, $(M-CH_3)^+$), 175 (20), 173 (25), 165 (53).- (Found: C, 52.68; H, 8.35. $C_{17}H_{32}O_2Sn$ (387.1) requires C, 52.74; H, 8.33.)

(±)-3c,8-Dimethoxy-5,5-dimethyl-1ξ-trimethylstannyl-(4ar)-1,2,3,4,4a,5,6,7-octahydro-naphthalene (25).
^{1}H NMR (80 MHz, $CDCl_3$): δ = 0.05 (s and 2d's, $J_{117Sn,1H}$ = 49 Hz, $J_{119Sn,1H}$ = 51 Hz, 9H; $Sn(CH_3)_3$, 0.80 (s, 3H; CH_3), 0.92 (s, 3H; CH_3), 2.90-3.25 (m, 1H; >C<u>H</u>-OCH_3), 3.35 (s, 3H; OCH_3), 3.44 (s, 3H; OCH_3).- IR (CCl_4): 1655 cm^{-1} (C=C-OR).- MS: m/z (%) = 388 (1, M^+), 373 (3), 223 (81), 165 (100), 86 (64), 84 (97).- (Found: 384.1423. $C_{17}H_{32}O_2{}^{116}Sn$ requires 384.1420)

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