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Remote Substituent Effect on the Electrophilic Additions of 1,3-Dienes. Synthesis of (2R)-5-(Acetoxymethyl)-2-acetyl-1,2,3,4-tetrahydro-10-methoxynaphthacene-2,12-diyl Diacetate.

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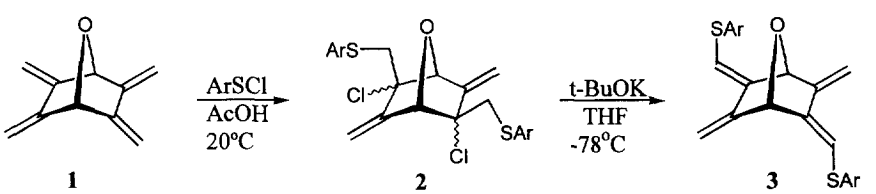
Abstract: The addition of one equivalent of 2-nitrobenzenesulfenyl chloride to 1-(dimethoxymethyl)-2,3,5,6-tetramethylidene-7-oxabicyclo[2.2.1]heptane (**4**) is highly regioselective giving 2-(chloromethyl)-1-(dimethoxymethyl)-5,6-dimethylidene-3-[(2-nitrophenylthio)methyl]-7-oxabicyclo[2.2.1]hept-2-ene (**9**). The reaction of 2-nitrobenzenesulfenyl chloride with 8-(dimethoxymethyl)-9,10-dimethylidene-11-oxatricyclo[6.2.1.$0^{2,7}$]undec-2(7)-en-4-yl methyl ketone derivatives (**5**, (-)-**6**) was also regioselective giving mixtures of 1,2- rather than 1,4-adducts resulting from competitive Markovnikov and anti-Markovnikov modes of addition, the olefinic moiety the furthest from the 8-dimethoxymethyl substituent being preferred. These adducts underwent base-induced eliminations with the formation of exocyclic thio- and chlorosubstituted dienes that added to 2,3-didehydroanisole to give products resulting from highly "ortho" regioselective Diels-Alder additions. The regioselectivity was the same whether 2,3-didehydroanisole was generated by nitrosation of 3-methoxy- or 6-methoxy-2-aminobenzoic acid. By applying these regioselective reactions to the Diels-Alder monoadduct of 3'-oxobut-2'-en-2'-yl (1R,5S,7S)-3-ethyl-2-oxo-3-aza-6,8-dioxabicyclo[3.2.1]octane-7-carboxylate (1-acetylvinyl RADO(Et)) with 1-(dimethoxymethyl)-2,3,5,6-tetramethylidene-7-oxabicylo[2.2.1]heptane (**4**), enantiopure (2R)-2-acetyl-1,2,3,4-tetrahydro-10-methoxynaphthacene-2,5-diyl diacetate and (2R)-5-(acetoxymethyl)-2-acetyl-1,2,3,4-tetrahydro-10-methoxynaphthacene-2,12-diyl diacetate were prepared.

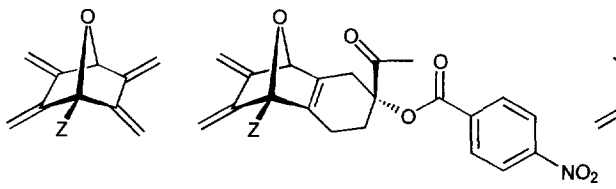
INTRODUCTION.

The double addition of 2-nitrobenzenesulfenyl chloride to the tetraene **1** gives an unstable bisadduct mixture **2** from which the major isomer precipitates and undergoes double elimination of HCl, when treated with t-BuOK in THF to give the C_2 disubstituted tetraene **3**[1,2]. The high regioselectivity of the double addition **1** → **2** can be interpreted in terms of either kinetic control (long-range substituent effect of the tetraene monoadduct on the regioselectivity of the electrophilic addition of the second 1,3-diene moiety) or of a preferential stabilization of one bisadduct (thermodynamic control). The double elimination of HCl is also highly stereoselective.

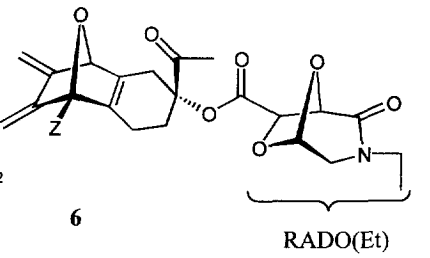


1 **2** **3**

We report here our study on the addition of 2-nitrobenzenesulfenyl chloride to the tetraene **4**[3] which bears an acetal moiety on one bridgehead centre and to the Diels-Alder adducts **5**[4] and (-)-**6**[5] of **4** to 2-acetylvinyl esters[6]. As we shall see, the dimethoxymethyl substituent induces high regioselectivity in these additions which lead to mixtures of "Markovnikov" and "*anti*-Markovnikov" monoadducts; their



4 **5** Z=CH(OMe)$_2$



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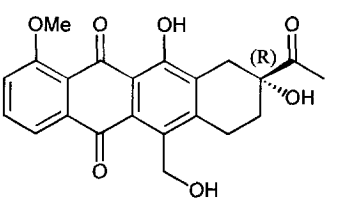
RADO(Et)

proportion depends on the nature of the remote environment of the conjugated diene. The adducts thus obtained with the optically active triene (-)-**6** were converted into enantiomerically pure potential precursors of anthracyclinones of type **7** ((R)-4-demethoxy-6,7-dideoxy-6-(hydroxymethyl)-1-methoxydaunomycinone; Brockmann atom numbering[7]) and **8** ((R)-4-demethoxy-7,11-dideoxy-1-methoxydaunomycinone).



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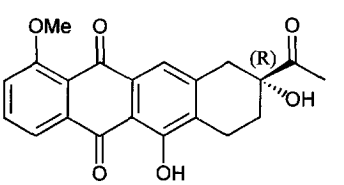

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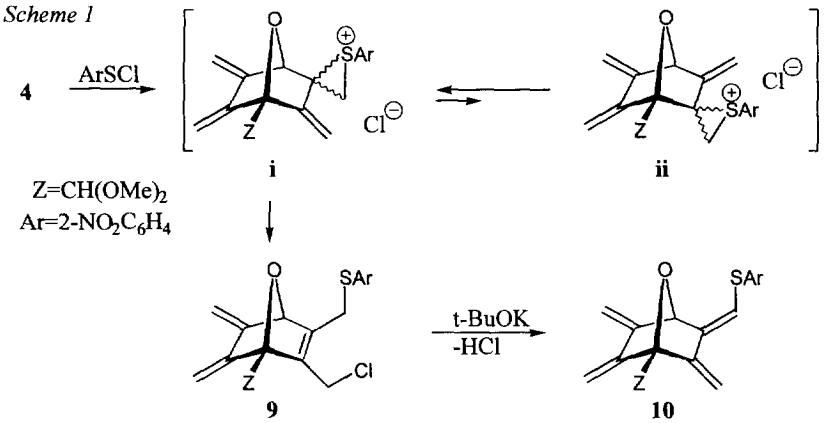
RESULTS AND DISCUSSION.

In the presence of 1.5 equivalents of 2-nitrobenzenesulfenyl chloride in acetonitrile, tetraene **4**[3] gave a single adduct **9** corresponding to a 1,4-addition (*Scheme 1*), which was subsequently isolated in 65% yield by column chromatography on silica gel at -20°C. This structure was deduced from its spectral data and confirmed by ^{1}H-NMR NOE measurements. It was further confirmed by its transformation into the thiotetraene **10** by treatment with t-BuOK (3 equivalents) in THF. The structure of **10** was confirmed by ^{1}H-NMR NOE measurements. With acyclic conjugated dienes, arenesulfenyl chloride is known to give first 1,2-adducts under kinetically controlled conditions. These adducts can then be isomerized to the more stable 1,4-adducts[8]. In order to test whether **9** was the adduct of kinetic rather than of thermodynamic control, we carried out the reaction of **4** + 2-$NO_2C_6H_4SCl$ in the more ionizing solvents hexafluoroisopropanol or 4 M $LiClO_4$ in acetic acid. Under these conditions only decomposition of **4** was observed. One can therefore not conclude whether **9** is an adduct arising from a kinetic or a thermodynamic control. However, it is interesting to note that both reactions **4** + 2-$NO_2C_6H_4SCl$ → **9** and **9** → **10** + HCl are highly stereoselective. If **9** should arise from a kinetically controlled reaction, it could be interpreted in terms of the formation of the bridged sulfonium ion intermediate **i**[9,10] which is expected to be more stable than the regioisomeric ion **ii**, because the former is less destabilized by the permanent dipole of the dimethoxymethyl substituent compared to the latter.

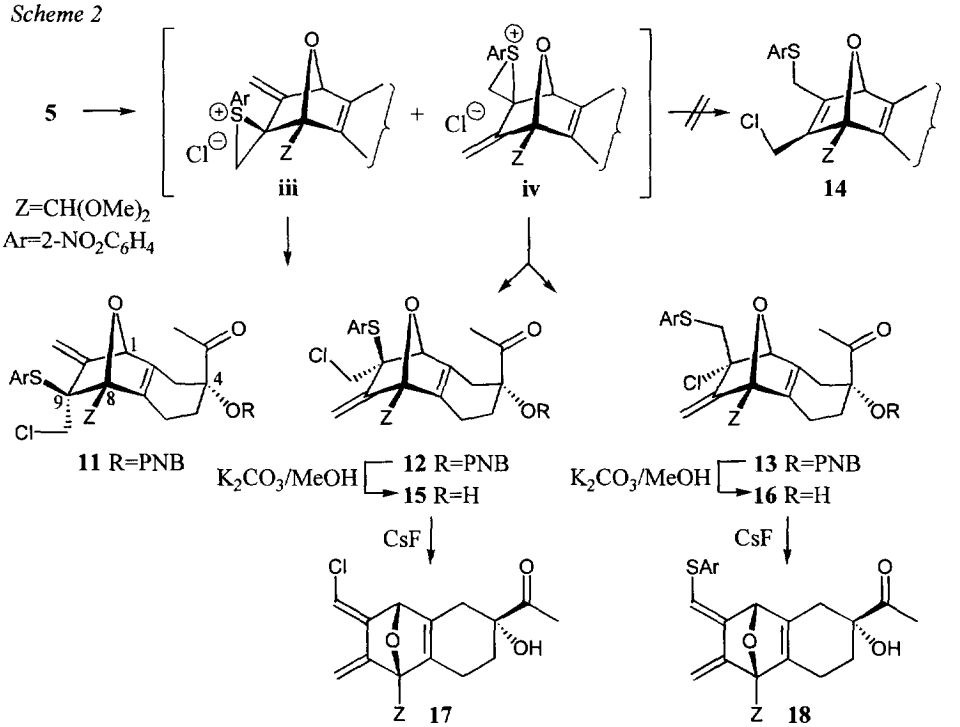
Scheme 1



Attempts to add 2-$NO_2C_6H_4SCl$ to **9** and **10** did not meet with any success. In CH_3CN at 55°C, triene **9** did not react after 5 h, whereas at higher temperatures decomposition was observed. In contrast, tetraene **10** reacted rapidly with 2-$NO_2C_6H_4SCl$ giving intractable mixtures.

In the presence of 1.5 equivalents of 2-$NO_2C_6H_4SCl$ in CH_3CN, triene **5** (40°C, 5 h) gave a 17:51:31 mixture of monoadducts **11**, **12** and **13** (*Scheme 2*). Their proportion did not vary during the course of the reaction (by ^{1}H-NMR) suggesting that these adducts arise from a kinetically controlled reaction. In the presence of 4 molar $LiClO_4$, rapid decomposition of **5** was observed. Adducts **11**, **12** and **13** could be

Scheme 2



separated and purified by column chromatography on silica gel at -20°C to give yields of 12%, 34% and 19%, respectively. The regioisomers **11** and **12** correspond to the *anti*-Markovnikov mode of addition, whereas **13** arises from the expected Markovnikov mode of addition. As for the addition of tetraene **4**, the major adducts (**12** + **13**) might arise from kinetic control; the electrophile attacks preferentially the exocyclic 1,3-diene moiety at the centres remote from the electron-withdrawing dimethyl acetal group leading to the major bridged sulfonium ion intermediate which is quenched by the chloride anion at the primary (→**12**) and tertiary centre (→**13**). Adduct **11** would arise from the quenching of intermediate **iii** by the chloride anion. The *exo* face mode of addition was expected for steric reasons; ^{1}H-NMR NOE measurements on **11**, **12** and **13** did not however allow this to be established unambigously, but they do confirm the other features of these structures. It is interesting to note that no adducts of 1,4-addition leading to 7-oxabicyclo[2.2.1]hepta-2,5-diene systems **14** has been detected, contrary to the electrophilic addition of tetraene **4** to 2-$NO_2C_6H_4SCl$. This observation might be interpreted in terms of the enhanced strain expected for bicyclo[2.2.1]hepta-2,5-diene derivatives compared with 5-methylidenebicyclo[2.2.1]hept-2-ene and 5,6-dimethylidenebicyclo[2.2.1]hept-2-ene systems[11]. The increased strain could manifest itself as a retarding factor in the quenching of intermediate **iii** by the chloride anion[12], or could make adducts of type **14** unstable compared with the reactants.

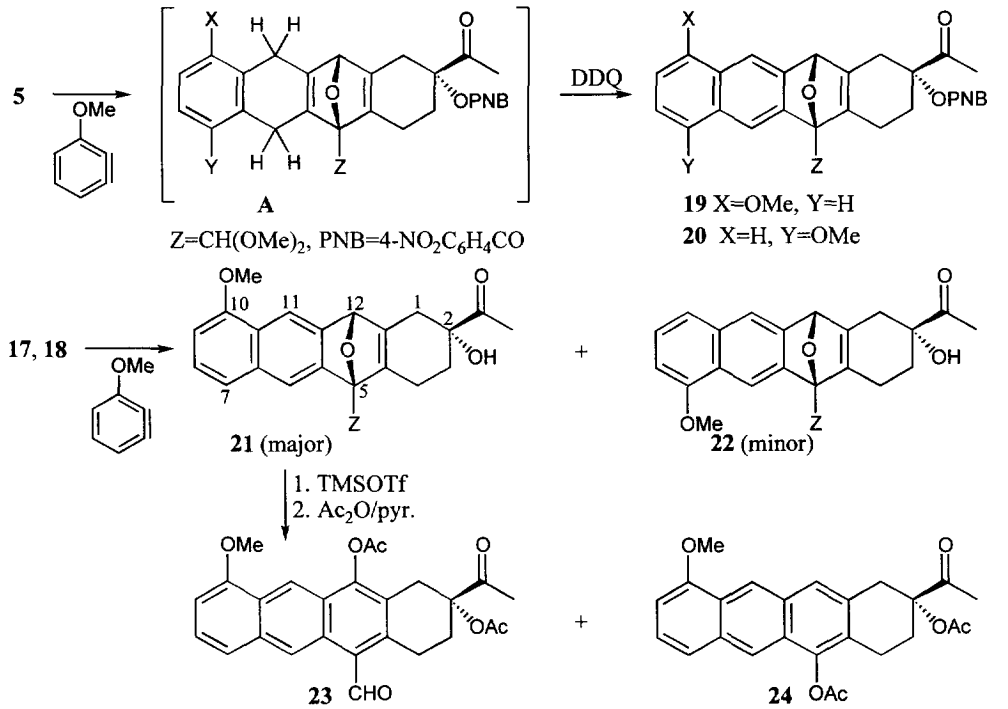
Treatment of **12** and **13** with anhyd. K_2CO_3 in MeOH/CH_2Cl_2 2:1 led to the alcohols **15** (81%) and **16** (86%), respectively. In the presence of t-BuOK in THF **15** and **16** were found to decompose. The smooth elimination of ArSH from **15** and of HCl from **16** could be achieved on heating these adducts in DMF in the presence of an excess of anhyd. CsF. The substituted trienes **17** and **18** were obtained in 59% and 97% yield, respectively. The (Z)-substituted exocyclic dienes, whose structures were established by ^{1}H-NMR NOE measurements, were the only isolated products.

The Diels-Alder addition of 2,3-didehydroanisole (generated by reaction of 2-amino-6-methoxybenzoic acid with isopentyl nitrite[13]) with the triene **5** gave a 57:43 mixture of the two regioisomeric products **19** and **20**, resulting from the [4+2]-cycloaddition followed by dehydrogenation with 2,3-dichloro-5,6-dicyano-benzoquinone of the intermediate adducts **A** (*Scheme 3*). Under the same conditions, the chlorodiene **17** gave a 91:9 mixture of **21** and **22** (70% yield) resulting from the Diels-Alder addition of 2,3-didehydroanisole followed by 1,4-elimination of HCl. Similarly, the thiodiene **18** added to 2,3-didehydroanisole giving an unstable mixture of adducts that underwent 1,4-elimination of 2-$NO_2C_6H_4SH$ leading to a 96:4 mixture of products **21** and **22** (47% yield, recovery of 36% of **18**). Saponification (0.1 N NaOH) of the p-nitrobenzoates **19** and **20** gave alcohols **21** and **22**, respectively. The ^{1}H-NMR NOE measurements of **21** confirmed its structure and confirmed the high "ortho" regioselectivity of the Diels-Alder addition of 2,3-didehydroanisole with the 1-chloro- and 1-(2-nitrophenylthio) dienes[2]. When 2,3-didehydroanisole was generated by reaction of isopentyl nitrite with 2-amino-3-methoxy-benzoic acid[14] instead of 2-amino-6-methoxybenzoic acid, the same products were obtained with the same regioselectivity thus establishing that the 2,3-didehydroanisole was the reacting species with the substituted diene rather than a cationic intermediate resulting from the deamination of the anthranilic acid derivatives[15].

Treatment of the 91:9 or 96:4 mixture of **21** + **22** with $(CH_3)_3SiOSO_2CF_3$ in CH_2Cl_2 at 0°C led to oxa bridge opening in the 7-oxabicyclo[2.2.1]hepta-2,5-diene moiety with the formation of phenolic products[4,5] which were not isolated, but were directly acetylated to give **23** and **24**. These products were isolated by

column chromatography in 48% and 14% yield, respectively. Other minor products resulting from the minor isomer **22** were eliminated during the purification process.

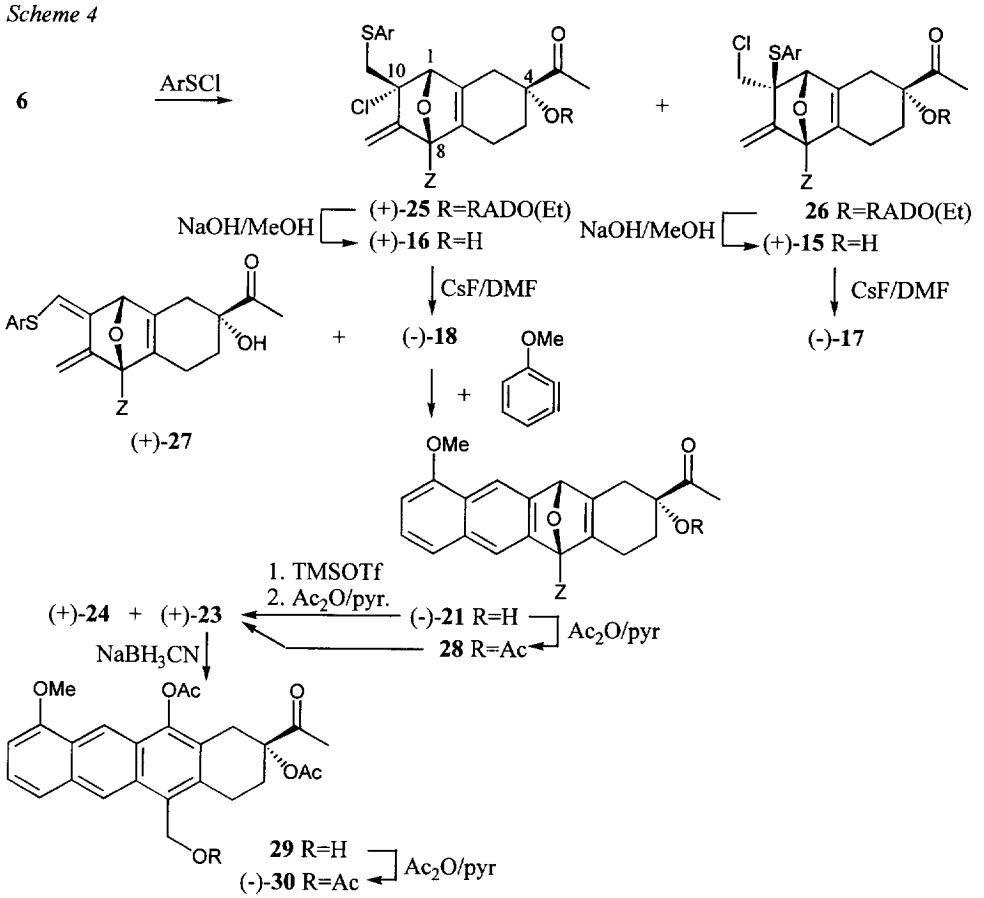
Scheme 3



Application of this sequence of reactions described above to the optically pure triene (-)-**6** (d.e. >99% by ^{1}H-NMR, ^{13}C satellite signals) enabled us to prepare enantiopure (R)-10-methoxy-1,2,3,4-tetrahydro-2-naphthacenyl methyl ketone derivatives (+)-**23**, (+)-**24** and (-)-**30** (*Scheme 4*). The absolute configuration of (-)-**6** has been previously established by chemical correlation and CD methods[5]. The addition of 2-nitrobenzenesulfenyl chloride in CH_3CN (40°C) to (-)-**6** gave a mixture of products from which (+)-**25** and **26** were isolated in 10% and 15% yield, respectively. Better yields were obtained when the reaction was run in AcOH at 55°C. In this case, the Markovnikov adduct (+)-**25** (40%) was obtained in preference to the *anti*-Markovnikov adduct **26** (12%). The yields and selectivity could not be improved on adding LiCl or $LiClO_4$. Saponification of (+)-**25** and **26** with 1 N NaOH in MeOH/H_2O afforded alcohols (+)-**16** (71%) and (+)-**15** (79%), respectively. Heating of (+)-**16** in DMF (80°C) in the presence of 10 equivalents of CsF gave the (Z)-thiodiene (-)-**18** (78%) and its (E)-isomer (+)-**27** (15%). Under similar conditions (85°C) (+)-**15** afforded the (Z)-chlorodiene (-)-**17** (60%). The two dienes (-)-**17** and (-)-**18** were added to 2,3-dihydroanisole giving the expected major product (-)-**21** with yields up to 70%. Treatment of (-)-**21** with $Me_3SiOSO_2CF_3$ (CH_2Cl_2, -8°C) followed by acetylation (Ac_2O/pyridine) afforded (+)-**23** (48%) and (+)-**24** (14%). When the tertiary alcohol of (-)-**21** was transformed by acetylation to **28** (74%) and then treated with $Me_3SiOSO_2CF_3$, (+)-**23** and (+)-**24** were isolated in 59% and 17% yield, respectively. Selective reduction of the aldehyde (+)-**23** with $NaBH_3CN$ in MeOH/$CHCl_3$/AcOH gave the benzylic alcohol **29**, which upon acetylation afforded the

triacetate (-)-**30** (66%). Oxidation of the anthracene moieties of (+)-**24** and (-)-**30** and saponification are expected to generate enantiomerically pure anthracyclinone derivatives of type **8** and **7**, respectively.

Scheme 4



CONCLUSION.

A remote dimethoxymethyl group is capable of controlling the regioselectivity of the electrophilic addition of 2-nitrobenzenesulfenyl chloride to a conjugated diene. The Diels-Alder additions of 2,3-didehydroanisole which *s-cis*-butadienes substituted at C(1) by a 2-nitrophenylthio or a chloro substituent are highly "ortho" regioselective[2,16]. The same regioselectivity was observed whether 2,3-didehydroanisole is generated by nitrosation of 6-methoxy- or 3-methoxy-2-aminobenzoic acid. By applying these reactions to the Diels-Alder monoadduct of 3'-oxobut-2'-en-2'-yl (1R,5S,7R)-3-ethyl-2-oxo-3-aza-6,8-dioxabicyclo[3.2.1]octan-7-carboxylate (1-acetylvinyl RADO(Et)) with 1-(dimethoxymethyl)-2,3,5,6-tetramethylidene-7-oxabicyclo[2.2.1]heptane, enantiomerically pure (2R)-2-acetyl-1,2,3,4-tetrahydro-10-methoxynaphthacene-2,5-diyl diacetate and (2R)-5-(acetoxymethyl)-2-acetyl-1,2,3,4-tetrahydro-10-methoxynaphthacene-2,12-diyl diacetate were prepared. These compounds are potential precursors for new enantiopure anthracyclinone analogues.

EXPERIMENTAL PART.

General. See ref. 17; FC = flash chromatography on silica gel.

(1RS,4SR)-2-(Chloromethyl)-1-(dimethoxymethyl)-5,6-dimethylidene-3-[(2-nitrophenylthio)methyl]-7-oxabicyclo[2.2.1]hept-2-ene (**9**). 2-Nitrobenzenesulfenyl chloride (NBSCl) (25.8 mg, 136 μmol) was added to a stirred soln. of **4** (20 mg, 91 μmol) in anhyd. CH_3CN (1 ml) under Ar atm. After stirring at 20°C for 3 h the solvent was evaporated. The oily residue was taken up in CH_2Cl_2 (5 ml), and the soln. was washed with H_2O (5 ml, 3 times) and dried ($MgSO_4$). The solvent was evaporated and the residue purified by FC (EtOAc/light petroleum 1:4) at -20°C. Crystallization from Et_2O/light petroleum 1:1 (-20°C) gave 24 mg (65%), yellow crystals m.p. 111-113°C, unstable compound. IR (KBr) ν: 2980, 2930, 2830, 1590, 1560, 1510, 1450, 1330, 1300, 1250, 1190, 1150, 1100, 1060, 980, 930, 900, 850, 800, 780, 730, 710 cm^{-1}. ^{1}H-NMR (250 MHz, $CDCl_3$) δ_H: 8.21 (dd, ^3J = 8.2, ^4J = 1.5); 7.53-7.49 (m); 7.38-7.25 (m); 5.33, 5.30, 5.21, 5.13, 4.99, 4.98 (6s, H-C(1), H-C(4), H_2C=C(5), H_2C=C(6)); 4.46, 4.39 (2d, ^2J = 12.0, H_2C-C(3)); 3.94, 3.82 (2d, ^2J = 14.6, CH_2C-C(2)); 3.57, 3.56 (2s, 2 MeO). ^{13}C-NMR (100.61 MHz, $CDCl_3$) δ_C: 133.6 (d, ^1J(C,H) = 165); 127.5 (d, ^1J(C,H) = 158); 125.9 (d, ^1J(C,H) = 159); 125.2 (d, ^1J(C,H) = 165); 105.4, 104.4, 102.8 (3s); 104.0, 103.1 (2t, ^1J(C,H) = 161, H_2C=C(5), H_2C=C(6)); 102.7 (d, ^1J(C,H) = 159, HC-C(1)); 83.4 (d, ^1J(C,H) = 167, C(4)); 56.7 (2q, ^1J(C,H) = 143, 2 MeO); 36.0 (t, ^1J(C,H) = 153, $ClCH_2$); 28.4 (t, ^1J(C,H) = 141, SCH_2). CI-MS (NH_3) m/z: 427 (2, $M^{+\bullet}$+18), 179 (12), 129 (7), 96 (8), 91 (13), 81 (9), 77 (7), 76 (6), 75 (100, $[CH(OMe)_2]^+$).

(1RS,4SR)-1-(Dimethoxymethyl)-2,5,6-trimethylidene-3-[(Z)-(2-nitrophenylthio)methylidene]-7-oxabicyclo-[2.2.1]heptane (**10**). NBSCl (103 mg, 0.54 mmol) was added to a stirred soln. of **4** (60 mg, 0.27 mmol) in anhyd. CH_3CN (3 ml) under Ar atm. After stirring at 20°C for 3 h the solvent was evaporated. The residue was taken up in CH_2Cl_2 (10 ml) and washed with H_2O (10 ml, 3 times). After drying ($MgSO_4$) and the solvent evaporation the residue was dissolved in anhyd. THF (3 ml), cooled to -78°C and t-BuOK (92 mg, 0.82 mmol) was added. The cooling bath was removed and the mixture was stirred for 16 h under Ar atm. H_2O (3 ml) and brine (3 ml) were added. The mixture was extracted with CH_2Cl_2 (5 ml, 3 times). The combined extracts were dried ($MgSO_4$) and the solvent was evaporated. The residue was purified by FC (EtOAc/light petroleum 1:4). The yellow oil obtained was crystallized from Et_2O and light petroleum (1:1) at -20°C: 44 mg (43%), yellow crystals, m.p. 121-122°C. UV (CH_3CN) λ_{max}: 330 (6300), 309 (10100), 231 (25400), 195 (23700). IR (KBr) ν: 2980, 2950, 2920, 2820, 1590, 1560, 1510, 1450, 1340, 1300, 1250, 1205, 1185, 1145, 1100, 1080, 1035, 1015, 950, 925, 900, 850, 830, 785, 740, 715, 655 cm^{-1}. ^{1}H-NMR (250 MHz, $CDCl_3$) δ_H: 8.24 (dd, ^3J = 8.2, ^4J = 1.4); 7.59-7.55 (m); 7.46 (dd, ^3J = 8.2, ^4J = 1.4); 7.37-7.30 (m); 6.42 (d, ^4J = 1.2, HC=C(3)); 5.57 (s, H-C(4)); 5.51 (s, H-C(1)); 5.50 (s, (E)-HC=C(2)); 5.44 (s, (E)-HC=C(6)); 5.42 (s, (Z)-HC=C(6)); 5.34 (s, (E)-HC=C(5)); 5.21 (s, (Z)-HC=C(5)); 4.88 (s, CH-C(1)); 3.62 (s, 2 MeO); the signal assignments were confirmed by NOE measurements. ^{13}C-NMR (100.61 MHz, $CDCl_3$) δ_C: 134.4 (d, ^1J(C,H) = 163); 129.6 (d, ^1J(C,H) = 166); 126.7 (d, ^1J(C,H) = 168); 126.4 (d, ^1J(C,H) = 165); 109.7 (d, ^1J(C,H) = 175, CH=C(3)); 105.2 (d, ^1J(C,H) = 159, HC-C(1)); 105.7, 104.9, 103.9 (3t, ^1J(C,H) = 107, H_2C=C(2), H_2C=C(5), H_2C=C(6)); 83.2 (d, ^1J(C,H) = 162, C(4)); 57.9, 57.8 (2q, ^1J(C,H) = 145, 2 MeO). CI-MS (NH_3) m/z: 373 (3, $M^{+\bullet}$), 175 (10), 163 (6), 147 (7), 138 (6), 134 (10), 125 (14), 123 (6), 115 (10), 98 (7), 89 (13), 78 (6), 75 (100), 71 (11). Anal. calc. for $C_{19}H_{19}O_5NS$ (373.42): C 61.11, H 5.13, S 8.59; found: C 61.02, H 5.21, S 8.67.

(1RS,4SR,8SR or 9SR)-4-acetyl-9-(chloromethyl)-8-(dimethoxymethyl)-10-methylidene-9-(2-nitrophenyl)thio)-11-oxatricyclo[6.2.1.0^{2,7}]undec-2(7)-en-4-yl 4-nitrobenzoate (**11**), *(1RS,4SR,8SR,10RS or 10SR)-4-acetyl-10-(chloromethyl)-8-(dimethoxymethyl)-9-methylidene-10-(2-nitrophenylthio)-11-oxatricyclo[6.2.1.0^{2,7}]undec-2(7)-en-4-yl 4-nitrobenzoate* (**12**) and *(1RS,4SR,8SR,10RS or 10SR)-4-acetyl-10-chloro-8-(dimethoxymethyl)-9-methylidene-10-[(2-nitrophenylthio)methyl]-11-oxatricyclo[6.2.1.0^{2,7}]undec-2(7)-en-4-yl 4-nitrobenzoate* (**13**). A mixture of **5** (333 mg, 0.73 mmol), NBSCl (209 mg, 1.1 mmol) and anhyd. CH_3CN (16 ml) was stirred at 40°C under Ar atm. for 5 h. The solvent was evaporated and the residue was dissolved in CH_2Cl_2 (50 ml). The soln. was washed with H_2O (20 ml, 3 times), dried ($MgSO_4$) and the solvent evaporated. The residue was separated by FC (EtOAc/light petroleum 3:2) at -20°C giving **11** (58 mg, 12%), **12** (160 mg, 34%), and **13** (88 mg, 19%).

Data of **11**: yellow crystals, m.p. 144-146°C. IR (KBr) ν: 3100, 3070, 2930, 2830, 1720, 1605, 1525, 1430, 1350, 1285, 1230, 1195, 1100, 1075, 1010, 995, 920, 905, 870, 845, 790, 720, 605 cm^{-1}. ^{1}H-NMR (250 MHz, $CDCl_3$) δ_H: 8.29 (dm, 2 H, ^3J = 8.9); 8.08 (dm, 2 H, ^3J = 8.9); 7.90-7.86 (m, 1 H); 7.67-7.63 (m, 1 H); 7.49-7.42 (m, 2 H); 5.10 (s, HC-C(8)); 4.96, 4.86 (2s, H_2C=C(10)); 4.63 (s, H-C(1)); 3.96, 3.28 (2d, ^2J = 11.8, ClH_2C-C(9)); 3.62, 3.43 (2s, 2 MeO); 2.97-2.89 (m, H_{exo}-C(3)); 2.81-2.75 (m, H_{exo}-C(6)); 2.55-2.44 (m, H_{endo}-C(3), H_{exo}-C(5)); 2.21 (s, CH_3CO); 2.05-1.97 (m, H_{endo}-C(5), H_{endo}-C(6)). ^{13}C-NMR (100.61 MHz, $CDCl_3$) δ_C: 204.6 (s, CO); 163.7 (s, COO); 155.4, 150.8, 146.9, 140.4, 139.8, 134.1, 126.7, 96.6, 85.2, 65.9 (10s); 141.0 (d, ^1J(C,H) = 173); 131.0 (d, ^1J(C,H) = 164); 130.8 (d, ^1J(C,H) = 163); 129.6 (d, ^1J(C,H) = 168); 123.9 (d, ^1J(C,H) = 172), 123.7 (d, ^1J(C,H) = 172); 109.9 (t, ^1J(C,H) = 160, H_2C=C(10)); 105.1 (d, ^1J(C,H) = 162); 92.0 (s, C(8)); 84.0 (d, ^1J(C,H) = 166, C(1)); 59.1, 56.7 (2q, ^1J(C,H) = 139, 2 MeO); 50.9 (t, ^1J(C,H) = 153, $ClCH_2$-C(9); 24.3 (q, ^1J(C,H) = 128, CH_3); 28.0, 27.7, 21.0 (3t, ^1J(C,H) = 131, C(3), C(5), C(6)). CI-MS (NH_3) m/z: 662 (2, $M^{+\bullet}$+18), 474 (32), 458 (36), 372 (35), 205 (90), 190 (45), 167 (54), 150 (48), 121 (57), 115 (51), 109 (58), 108 (34), 104 (100), 103 (30).

Data of **12**: yellow crystals, m.p. 152-154°C. IR (KBr) ν: 3100, 3070, 2950, 2920, 2820, 1720, 1710, 1600, 1525, 1440, 1430, 1345, 1280, 1230, 1190, 1095, 1070, 1055, 1005, 930, 910, 870, 845, 830, 810, 780, 730, 715, 650 cm^{-1}. ^{1}H-NMR (250 MHz, $CDCl_3$) δ_H: 8.26 (dm, ^3J = 8.9); 8.00 (dm, 2 H, ^3J = 8.9); 7.84-7.80 (m, 1 H); 7.76-7.71 (m, 1 H); 7.55-7.51 (m, 2 H); 5.24, 4.45 (2s, H_2C=C(9)); 4.94 (s, H-C(1)); 4.37 (s, HC-C(8)); 3.60, 3.22 (2d, ^2J = 11.9, $ClCH_2$C(10)); 3.52, 3.50 (2s, 2 MeO); 3.03-2.79 (m, H_{exo}-C(3), H_{exo}-C(6)); 2.63-2.55 (m, H_{endo}-C(3)); 2.48-2.39 (m, H_{exo}-C(5)); 2.22 (s, MeCO); 2.18-1.98 (m, H_{endo}-C(5), H_{endo}-C(6)). ^{13}C-NMR (100.61 MHz, $CDCl_3$) δ_C: 205.6 (s, CO); 163.8 (s, COO); 150.8, 148.3, 143.4, 137.2, 134.7, 126.9, 125.3, 85.6, 65.0 (9s); 141.0 (d, ^1J(C,H) = 155); 131.2 (d, ^1J(C,H) = 164); 130.5 (d, ^1J(C,H) = 160); 124.0 (d, ^1J(C,H) = 169); 123.7 (d, ^1J(C,H) = 171), 123.4 (d, ^1J(C,H) = 171); 108.8 (dd, ^1J(C,H) = 158, H_2C=C(9)); 104.4 (d, ^1J(C,H) = 160, HC-C(8)); 92.0 (s, C(8)); 85.9 (d, ^1J(C,H) = 169, C(1)); 57.8, 56.9 (2q, ^1J(C,H) = 143, 2 MeO); 50.5 (t, ^1J(C,H) = 153, $ClCH_2$-C(10)); 24.2 (q, ^1J(C,H) = 129, Me); 29.9, 27.2, 18.5 (3t, ^1J(C,H) = 131, C(3), C(5), C(6)). CI-MS (NH_3) m/z: 662 (16, $M^{+\bullet}$+18), 462 (10), 392 (11), 326 (10), 240 (13), 100 (17), 88 (11), 75 (100).

Data of **13**: yellow crystals, m.p. 177-179°C. IR (KBr) ν: 3100, 3070, 2950, 2920, 2830, 1720, 1710, 1600, 1525, 1440, 1425, 1345, 1280, 1230, 1190, 1095, 1070, 1005, 930, 910, 870, 845, 830, 810, 780, 730, 715, 650 cm^{-1}. ^{1}H-NMR (250 MHz, $CDCl_3$) δ_H: 8.27-8.08 (m, 5 H); 7.57-7.46 (m, 2 H); 7.31-7.25 (m, 1 H); 5.52,

5.38 (2s, H_2C=C(9)); 5.01 (s, H-C(1)); 4.72 (s, HC-C(8)); 3.60-3.58 (m, 8 H, MeO, CH_2-C(10)); 3.09-2.87 (m, H_{exo}-C(3), H_{exo}-C(6)); 2.68-2.57 (m, H_{endo}-C(3)); 2.45-2.23 (m, H_{exo}-C(5), H_{endo}-C(6)); 2.21 (s, Me); 2.25-1.92 (m, H_{endo}-C(5)). ^{13}C-NMR (100.61 MHz, $CDCl_3$) δ_C: 205.1 (s, CO); 163.7 (s, COO); 150.6, 149.7, 146.7, 141.3, 138.3, 136.2, 130.5, 91.6, 84.9, 71.8 (10s); 133.4 (d, ^1J(C,H) = 163); 131.0 (d, ^1J(C,H) = 170); 127.5 (d, ^1J(C,H) = 165); 125.9 (d, ^1J(C,H) = 168); 125.2 (d, ^1J(C,H) = 167); 123.3 (d, ^1J(C,H) = 171); 108.4 (t, ^1J(C,H) = 163, H_2C=C(9)); 103.7 (d, ^1J(C,H) = 159, HC-C(8)); 82.9 (d, ^1J(C,H) = 167, C(1)); 57.1, 23.9 (2 q, ^1J(C,H) = 143, 2 MeO); 45.3 (t, ^1J(C,H) = 144, CH_2-C(10)); 29.8, 27.6, 18.5 (3 t, ^1J(C,H) = 131, C(3), C(5), C(6)); 23.9 (q, ^1J(C,H) = 128, Me). CI-MS (NH_3) m/z: 662 (100, $M^{+\bullet}$+18), 631 (74), 627 (36), 617 (24), 213 (21), 75 (80).

(1RS,4SR,8SR,10RS or 10SR)-10-(Chloromethyl)-4-hydroxy-8-(dimethoxymethyl)-9-methylidene-10-(2-nitrophenylthio)-11-oxatricyclo[6.2.1.0^{2,7}]undec-2(7)-en-4-yl methyl ketone (**15**). A mixture of **12** (160 mg, 0.25 mmol), anh. MeOH (30 ml), anhyd. CH_2Cl_2 (14 ml) and anhyd. K_2CO_3 (0.5 g) was stirred at 20°C for 40 min. The solvent was evaporated and the residue was taken up in H_2O (30 ml). Extraction with CH_2Cl_2 (30 ml, 4 times), drying ($MgSO_4$), solvent evaporation and FC on Florisil (EtOAc/light petroleum 1:1) gave 96 mg (81%), yellow solid, m.p. 51-54°C. UV (CH_3CN) λ_{max}: 220 (13000). IR (KBr) ν: 3440, 3050, 2990, 2910, 2820, 1700, 1520, 1440, 1350, 1300, 1275, 1185, 1100, 1070, 1025, 940, 910, 850, 815, 775, 735 cm^{-1}. ^{1}H-NMR (250 MHz, $CDCl_3$) δ_H: 7.87-7.83 (m, 1 H); 7.74-7.68 (m, 1 H); 7.54-7.49 (m, 2 H); 5.17, 4.37 (2 s, H_2C=C(9)); 4.90 (br. s, H-C(1)); 4.38 (s, CH-C(8)); 3.87 (s, OH), 3.75-3.65 (2d, ^2J = 12.2, $ClCH_2$-C(10)); 3.51, 3.50 (2s, 2 MeO); 2.75 (br. ddd, ^2J = 17.6, ^5J = 4.1, ^5J = 2.7, H_{exo}-C(3)); 2.47 (br. dm, ^2J = 17.3, H_{exo}-C(6)); 2.24 (s, Me); 2.30-2.04 (m, H_{endo}-C(3), H_{endo}-C(6)); 1.93 (ddd, ^2J = 12.6, ^3J = 12.5, ^3J = 5.7, H_{exo}-C(5)); 1.60-1.55 (m, H_{endo}-C(5)). ^{13}C-NMR (100.61 MHz, $CDCl_3$) δ_C: 211.3 (s, CO); 155.8, 147.3, 142.8, 137.1, 127.7, 125.7 (6s); 141.0, 131.0, 130.1, 123.8 (4d, ^1J(C,H) = 163-171); 108.6 (t, ^1J(C,H) = 158, CH_2=C(9)); 104.1 (d, ^1J(C,H) = 159, CH-C(8)); 92.1 (s, C(8)); 86.0 (d, ^1J(C,H) = 175, C(1)); 65.7 (s, C(4)); 57.4, 56.8 (2 q, ^1J(C,H) = 142, 2 MeO); 50.5 (t, ^1J(C,H) = 155, $ClCH_2$-C(10)); 32.3, 29.4 (2t, ^1J(C,H) = 130, C(3), C(6)); 23.6 (q, ^1J(C,H) = 129, Me); 18.1 (t, ^1J(C,H) = 129, C(5)). CI-MS (NH_3) m/z: 513 (7, $M^{+\bullet}$+18), 179 (5), 178 (16), 77 (6), 75 (100).

(1R,4S,8S,10R or 10S)-10-(Chloromethyl)-4-hydroxy-8-(dimethoxymethyl)-9-methylidene-10-(2'-nitrophenylthio)-11-oxatricyclo[6.2.1.0^{2,7}]undec-2(7)-en-4-yl methyl ketone ((+)-**15**). A 1 N aqueous solution of NaOH (125 µl) was added to a solution of **26** (70 mg, 0.103 mmol) in methanol (7 ml) cooled to -10°C. After stirring for 45 min, the mixture was diluted with CH_2Cl_2 (50 ml), washed with brine (25 ml, twice), dried ($MgSO_4$) and the solvent was evaporated. The residue was purified by FC (CH_2Cl_2/AcOEt 96:4) giving 40 mg (79%) of (+)-**15**, yellow solid, m.p. 49-51°C. $[\alpha]_{589}$ = 353, $[\alpha]_{577}$ = 373, $[\alpha]_{546}$ = 444 (c = 1.0, $CHCl_3$). Anal. calc. for $C_{23}H_{26}O_7NSCl$: C 55.70, H 5.28; found: C 55.70, H 5.38.

(1RS,4SR,8SR,10RS or 10SR)-10-Chloro-4-hydroxy-8-(dimethoxymethyl)-9-methylidene-10-[(2-nitrophenylthio)methyl]-11-oxatricyclo[6.2.1.0^{2,7}]undec-2(7)-en-4-yl methyl ketone (**16**). The same procedure as for the preparation of **15**, starting from **13** (98 mg, 0.15 mmol). Yield 65 mg (86%), yellow solid, m.p. 49-51°C. UV (CH_3CN) λ_{max}: 366 (2700), 242 (10100), 217 (8600 sh). IR (KBr) ν: 3500, 2920, 2830, 1710, 1590, 1560, 1510, 1450, 1430, 1330, 1300, 1195, 1100, 1075, 950, 850, 780, 735 cm^{-1}. ^{1}H-NMR (250 MHz, $CDCl_3$) δ_H: 8.16 (dd, ^3J = 8.1, ^4J = 1.2); 7.58-7.48 (m, 2 H); 7.28 (m, 1 H); 5.49, 5.45 (2s, CH_2=C(9)); 4.98 (br. s, H-

C(1)); 4.75 (s, CH-C(8)); 3.66, 3.56 (2d, ^2J = 13.1, CH_2-C(10)); 3.57, 3.55 (2s, 2 MeO); 2.89 (s, OH); 2.82 (br. ddd, ^2J = 15.9, ^5J = 3.8, ^5J = 1.9, H_{exo}-C(3)); 2.49 (br. dm, ^2J = 13.5, H_{exo}-C(6)); 2.31-2.23, 1.85-1.70 (2m, H_2-C(5), H_{endo}-C(3), H_{endo}-C(6)); 2.27 (s, Me). ^{13}C-NMR (100.61 MHz, $CDCl_3$) δ_C: 212.1 (s, CO), 149.2, 146.9, 141.7, 138.4, 136.3, 124.7 (6s); 133.4, 127.7, 126.0, 125.2 (4d, ^1J(C,H) = 162-174); 108.9 (dd, ^1J(C,H) = 163, ^1J(C,H) = 159, CH_2=C(10)); 103.1 (d, ^1J(C,H) = 159, CH-C(8)); 91.9 (s, C(8)); 82.9 (d, ^1J(C,H) = 167, C(1)); 72.5 (s, C(4)); 56.9, 56.6 (2q, ^1J(C,H) = 143, 2 MeO); 45.2 (t, ^1J(C,H) = 144, CH_2-C(9)); 32.3, 29.4 (2t, ^1J(C,H) = 131, C(3), C(6)); 24.5 (q, ^1J(C,H) = 128, Me); 18.1 (t, ^1J(C,H) = 131, C(5)). CI-MS (NH_3) m/z: 513 (9, $M^{+\bullet}$+18), 324 (2), 223 (2), 108 (2), 91 (3), 76 (3), 75 (100, $[CH(OMe)_2]^+$).

(1R,4S,8S,10R or 10S)-10-Chloro-4-hydroxy-8-(dimethoxymethyl)-9-methylidene-10-[(2'-nitrophenylthio)-methyl]-11-oxatricyclo[6.2.1.0^{2,7}]undec-2(7)-en-4-yl methyl ketone ((+)-**16**). The same procedure as for the preparation of (+)-**15**, starting from (+)-**25** (166 mg, 0.244 mmol). Purification by FC (EtOAc/light petroleum 1:1), yield: 89 mg (74%), yellow solid, m.p. 47-49°C. $[\alpha]_{589}$ = 107, $[\alpha]_{577}$ = 114, $[\alpha]_{546}$ = 135 (c = 1.1, $CHCl_3$). Anal. calc. for $C_{23}H_{26}O_7NSCl$ (495.98): C 55.70, H 5.28, S 6.46; found: C 55.83, H 5.35, S 6.52.

(1RS,4SR,8SR)-10-[(Z)-(Chloromethylidene)]-4-hydroxy-8-(dimethoxymethyl)-9-methylidene-11-oxatricyclo-[6.2.1.0^{2,7}]undec-2(7)-en-4-yl methyl ketone (**17**). A mixture of **15** (60 mg, 0.12 mmol), anhyd. DMF (5 ml) and anhyd. CsF (190 mg, 1.25 mmol) was heated to 110°C for 95 min. After cooling to 20°C, H_2O (30 ml) was added, the mixture was extracted with $CHCl_3$ (20 ml, 3 times). The combined extracts were dried ($MgSO_4$) and the solvent was evaporated. The residue was dissolved in toluene (20 ml) and the solvent was evaporated to dryness in vacuo. FC (light petroleum/AcOEt/CH_2Cl_2 3:1:1) gave 25 mg (59%) of a white solid that darkened rapidly. M.p. 51-54°C. UV (CH_3CN) λ_{max}: 240 (7000). IR (KBr) ν: 3470, 2990, 2920, 2830, 1705, 1645, 1440, 1355, 1190, 1175, 940, 895, 845, 610 cm^{-1}. ^{1}H-NMR (400 MHz, $CDCl_3$) δ_H: 6.22 (d, ^4J = 1.0, ClCH=C(10)); 5.44 (br. s, H-C(1)); 5.24, 5.22 (2s, CH_2=C(9)); 4.81 (s, CH-C(8)); 3.59, 3.57 (2s, 2 MeO); 3.29 (s, OH); 2.85 (br. ddd, ^2J = 17.6, ^5J = 3.9, ^5J = 2.8, H_{exo}-C(3)); 2.51 (br. dm, ^2J = 17.8, H_{exo}-C(6)); 2.27 (s, Me); 2.25-2.16 (m, H_{endo}-C(6)); 1.97-1.86 (m, H_{exo}-C(5), H_{endo}-C(3)); 1.69-1.61 (m, H_{endo}-C(5)). ^{13}C-NMR (100.61 MHz, $CDCl_3$) δ_C: 211.7 (s, CO); 142.4, 141.7, 139.7, 138.1 (4s); 108.1 (d, ^1J(C,H) = 197, ClCH=C(10)); 103.1 (d, ^1J(C,H) = 159, CH-C(8)); 102.6 (dd, ^1J(C,H) = 164, ^1J(C,H) = 158, CH_2=C(9)); 92.5 (s, C(8)); 80.7 (d, ^1J = 168, C(1)); 76.8 (s, C(4)); 56.6 (2q, ^1J(C,H) = 142, 2 MeO); 32.2, 29.9 (2t, ^1J(C,H) = 129, C(3), C(6)); 24.0 (q, ^1J(C,H) = 128, Me); 18.8 (t, ^1J(C,H) = 133, C(5)). CI-MS (NH_3) m/z: 358 (24, $M^{+\bullet}$+18), 297 (3, $[M\text{-}COCH_3]^+$), 291 (5), 94 (5), 91 (6), 86 (5), 76 (8), 75 (100).

(1R,4S,8S)-10-[(Z)-Chloromethylidene)]-4-hydroxy-8-(dimethoxymethyl)-9-methylidene-11-oxatricyclo-[6.2.1.0^{2,7}]undec-2(7)-en-4-yl methyl ketone ((-)-**17**). The same procedure as for the preparation of **17**, starting with (+)-**15** (58 mg, 0.117 mmol), yield: 24 mg (60%), colourless oil that darkens rapidly. $[\alpha]_{589}$ = -104, $[\alpha]_{577}$ = -111, $[\alpha]_{546}$ = -126, $[\alpha]_{435}$ = -237, $[\alpha]_{405}$ = -297 (c = 0.5, $CHCl_3$).

(1RS,4SR,8SR)-4-Hydroxy-8-(dimethoxymethyl)-9-methylidene-10-[(Z)-(2-nitrophenylthio)methylidene]-11-oxatricyclo[6.2.1.0^{2,7}]undec-2(7)-en-4-yl methyl ketone (**18**). The same procedure as for the preparation of **17**, starting from **16** (65 mg, 0.13 mmol) except in this case we heated to 80°C (90 min) instead of 110°C. Yield: 58 mg (97%), yellow solid, m.p. 58-61°C. UV (CH_3CN) λ_{max}: 379 (5100), 281 (13000), 239 (14500), 213 (14500). IR (KBr) ν: 3460, 3080, 2920, 2830, 1705, 1590, 1560, 1510, 1450, 1335, 1300, 1250, 1205, 1190,

1175, 1100, 1075, 1055, 1030, 1000, 975, 940, 920, 890, 860, 850, 810, 785, 735, 720, 655 cm^{-1}. ^{1}H-NMR (360 MHz, $CDCl_3$) δ_H: 8.21 (dd, ^3J = 7.8, ^4J = 1.5); 7.54 (ddd, ^3J = 7.8, ^3J = 6.9, ^4J = 1.4); 7.45 (dd, ^3J = 7.8, ^4J = 1.5); 7.30 (ddd, ^3J = 7.8, ^3J = 6.9, ^4J = 1.4); 6.30 (d, ^4J = 0.9, CH=C(10)); 5.56 (br. s, H-C(1)); 5.47 (s, (E)-H-C=C(9)); 5.35 (s, (Z)-H-C=C(9)); 4.86 (s, CH-C(8)); 3.61, 3.60 (2s, 2 MeO); 3.50 (s, OH); 2.80 (br. ddd, ^2J = 17.7, ^5J = 3.4, ^5J = 3.2, H_{exo}-C(3)); 2.53 (br. dm, ^2J = 18.0, H_{exo}-C(6)); 2.27-2.15 (br. m, H_{endo}-C(6)); 2.23 (s, Me); 1.94 (ddd, ^2J = 11.4, ^3J = 11.2, ^3J = 5.7, H_{exo}-C(5)); 1.81 (br. d, ^2J = 17.7, H_{endo}-C(3)), 1.68-1.59 (m, H_{endo}-C(5)). Proton assignments confirmed by NOE measurements. ^{13}C-NMR (100.61 MHz, $CDCl_3$) δ_C: 211.7 (s, CO); 148.7, 145.5, 143.0, 141.0, 138.0, 137.2 (6s); 133.7, 128.6, 125.9, 125.4 (4d, ^1J(C,H) = 161-168); 106.6 (d, ^1J(C,H) = 176, CH=C(10)); 103.8 (dd, ^1J(C,H) = 164, ^1J(C,H) = 158, CH_2=C(10)); 103.2 (d, ^1J(C,H) = 154, CH-C(8)); 92.2 (s, C(8)); 81.2 (d, ^1J(C,H) = 169, C(1)); 76.7 (s, C(4)); 56.8, 56.6 (2q, ^1J(C,H) = 143, 2 MeO); 32.0, 29.9 (2t, ^1J(C,H) = 129, C(3), C(6)); 23.9 (q, ^1J(C,H) = 128, Me); 19.0 (t, ^1J(C,H) = 131, C(5)). CI-MS (NH_3) m/z: 477 (4, $M^{+\bullet}$+18), 460 (4, $M^{+\bullet}$+1), 459 (6, $M^{+\bullet}$), 416 (7, $[M\text{-}COCH_3]^+$), 291 (10), 86 (20), 83 (28), 75 (100).

(1R,4S,8S)-4-Hydroxy-8-(dimethoxymethyl)-9-methylidene-10-[(Z)-(-2-nitrophenylthio)methylidene]-11-oxa-tricyclo[6.2.1.0^{2,7}]undec-2(7)-en-4-yl methyl ketone ((-)-**18**) and *(1R,4S,8S)-4-hydroxy-8-(dimethoxymethyl)-9-methylidene-10-[(E)-(2-nitrophenylthio)methylidene]-11-oxatricyclo[6.2.1.0^{2,7}]undec-2(7)-en-4-yl methyl ketone* ((+)-**27**). A mixture of (+)-**16** (83 mg, 0.167 mmol), anhyd. DMF (7.5 ml) and anhyd. CsF (251 mg, 1.67 mmol) was heated to 80°C for 90 min. The orange mixture was diluted with H_2O (50 ml) and extracted with CH_2Cl_2 (20 ml, twice). The combined extracts were washed with brine (20 ml, twice) and dried ($MgSO_4$). Solvent evaporation and FC (EtOAc/light petroleum 1:1) gave (-)-**18** (60 mg, 78%) and (+)-**27** (12 mg, 15%).

Data of (-)-**18**: yellow solid, m.p. 59-61°C. $[\alpha]_{589}$ = -202, $[\alpha]_{577}$ = -216, $[\alpha]_{546}$ = -270 (c = 1, $CHCl_3$). Anal. calc. for $C_{23}H_{25}O_7NS$ (459.53): C 60.12, H 5.48, N 3.05, S 6.98; found: C 60.19, H 5.55, N 3.01, S 6.98.

Data of (+)-**27**: yellow solid, m.p. 58-60°C. $[\alpha]_{589}$ = 36, $[\alpha]_{577}$ = 40, $[\alpha]_{546}$ = 65 (c = 0.5, $CHCl_3$). UV (CH_3CN): 383 (4900), 286 (13000), 244 (13300), 214 (14700). IR (KBr) ν: 3480, 2920, 2830, 1700, 1590, 1560, 1510, 1450, 1330, 1190, 1100, 1075, 940, 850, 780, 730 cm^{-1}. ^{1}H-NMR (400 MHz, $CDCl_3$) δ_H: 8.18 (d, ^3J = 7.9); 7.55-7.51 (m, 2 H); 7.34-7.29 (m, 1 H); 6.29 (s, H-C=C(10)); 6.12 (s, (E)-HC=C(9)); 5.53 (s, (Z)-HC=C(9)); 5.02 (br. s, H-C(1)); 4.86 (s, HC-C(8)); 3.60, 3.59 (2s, 2 MeO); 3.28 (s, OH); 2.84 (ddd, ^2J = 17.6, ^5J = 3.6, ^5J = 3.3, H_{exo}-C(3)); 2.53 (br. dm, ^2J = 18.0, H_{exo}-C(6)); 2.29 (s, MeCO); 2.30-2.21 (br. m, H_{endo}-C(6)); 2.01-1.90 (m, H_{exo}-C(5), H_{endo}-C(3)); 1.71-1.66 (m, 1 H, H_{endo}-C(5)). Proton assignments confirmed by NOE measurements. ^{13}C-NMR (100.61 MHz, $CDCl_3$) δ_C: 211.9 (s, CO); 146.3, 144.6, 143.0, 142.3, 138.3, 136.0 (6s); 133.6, 129.1, 125.8, 125.6 (4d, ^1J(C,H) = 163-169); 111.5 (d, ^1J(C,H) = 175, HC=C(10)); 110.4 (t, ^1J(C,H) = 179, H_2C=C(9)); 102.9 (d, ^1J(C,H) = 159, CH-C(8)); 92.9 (s, C(8)); 84.9 (d, ^1J(C,H) = 167, C(1)); 76.8 (s, C(4)); 56.7, 56.4 (2q, ^1J(C,H) = 144, 2 MeO); 31.8, 30.0 (2t, ^1J(C,H) = 128, C(3), C(6)); 24.1 (q, ^1J(C,H) = 128, MeCO); 18.8 (t, ^1J(C,H) = 131, C(5)). CI-MS (NH_3) m/z: 459 (1, $M^{+\bullet}$), 416 (1, $[M\text{-}CH_3CO]^+$), 304 (1, $[M\text{-}ArSH]^+$), 289 (5), 91 (8), 75 (100, $[CH(OMe_2]^+$). Anal. calc. for $C_{23}H_{25}O_7NS$ (459.53): C 60.12, H 5.48, S 6.98; found: C 60.26, H 5.55, S 6.92.

(2RS,5SR,12SR)-1,2,3,4,5,12-Hexahydro-2-hydroxy-10-methoxy-5-(dimethoxymethyl)-5,12-epoxynaphthacen-2-yl methyl ketone (**21**). A soln. of 2-amino-6-methoxybenzoic acid (46 mg, 0.27 mmol) in anhyd. PhH (1 ml) and dimethoxyethane (0.5 ml), and a solution of isopentyl nitrite (59 µl, 0.54 mmol) in anhyd. PhH (1 ml) were added simultaneously dropwise to a refluxing soln. of **18** (50 mg, 0.11 mmol) in anhyd. PhH (2 ml) and dimethoxyethane (1 ml) under Ar atm. At the end of the additions, the mixture was heated under reflux for 25 min. The mixture was cooled to 20°C and CH_2Cl_2 (30 ml) was added. The soln. was washed with sat. aq. soln. of $NaHCO_3$ (20 ml, 3 times), brine (20 ml, twice) and dried ($MgSO_4$). The solvent was evaporated and the residue purified by FC (CH_2Cl_2/EtOAc 12:1) giving 21 mg (47%) of **21** (R_f = 0.27) and 18 mg (36%) of **18** (R_f = 0.42). Data of **21**: m.p. 60-63°C. UV (CH_3CN) λ_{max}: 274 (7200 sh.), 266 (7500 sh.), 244 (14600). IR (KBr) ν: 3460, 3220, 2920, 2830, 1705, 1590, 1565, 1510, 1460, 1360, 1260, 1185, 1070, 885 cm^{-1}. ^{1}H-NMR (250 MHz, $CDCl_3$) δ_H: 7.95 (s, H-C(11)); 7.64 (s, H-C(6)); 7.36-7.33 (m, H-C(7), H-C(8)); 6.85-6.81 (m, H-C(9)); 5.51 (br. s, H-C(12)); 5.08 (s, CH-C(5)); 3.97 (s, MeO-C(10)); 3.72, 3.65 (2s, $CH(OMe)_2$); 2.87 (br. ddd, ^2J = 17.8, ^5J = 2.9, ^5J = 2.7, H_{exo}-C(1)); 2.62 (br. dm, ^2J = 17.5, H_{exo}-C(4)); 2.60 (s, OH); 2.19 (s, COMe); 2.17-2.01 (m, H_{endo}-C(4)); 1.94-1.77 (m, H_{exo}-C(3), H_{endo}-C(1)); 1.60-1.53 (m, H_{endo}-C(3)). Proton assignments confirmed by NOE measurements. ^{13}C-NMR (100.61 MHz, $CDCl_3$) δ_C: 211.9 (s, CO), 155.6, 146.1, 144.7, 144.3, 144.1, 133.0, 123.1 (7s); 125.9, 120.9, 118.4, 111.6, 104.9 (5d, ^1J(C,H) = 155-164); 93.1 (s, C(5)); 83.3 (d, ^1J(C,H) = 166, C(12)); 57.0 (2q, ^1J(C,H) = 143, $CH(OMe)_2$); 55.5 (q, ^1J(C,H) = 143, MeO-C(10)); 32.4, 30.1 (2t, ^1J(C,H) = 129, C(1), C(4)); 24.2 (q, ^1J(C,H) = 128, COMe); 19.6 (t, ^1J(C,H) = 129, C(3)). CI-MS (NH_3) m/z: (5, $M^{+\bullet}$), 335 (2, $[M\text{-}CH(OMe)_2]^+$), 76 (5), 75 (100).

(2R,5S,12R)-1,2,3,4,5,12-Hexahydro-2-hydroxy-10-methoxy-5-(dimethoxymethyl)-5,12-epoxynaphthacen-2-yl methyl ketone ((-)-**21**). The same procedure as for the preparation of **21**, starting with (-)-**18** (88 mg, 0.19 mmol) or with (-)-**17**, yields 31 mg (40%) yellowish solid, m.p. 70-73°C. $[\alpha]_{589}$ = -76, $[\alpha]_{577}$ = -80, $[\alpha]_{546}$ = -93 (c = 1.2, $CHCl_3$). Anal. calc. for $C_{24}H_{26}O_6$ (410.47): C 70.23, H 6.38; found: C 70.33, H 6.53.

*(1'R,4'R,8'S)-4'-Acetyl-10'-chloro-8'-(dimethoxymethyl)-9'-methylidene-10'-[(2''-nitrophenylthio)methyl]-11'-oxatricyclo[6.2.1.0^{2,7}]undec-2'(7')-en-4'-yl (1R,5S,7R)-3-ethyl-2-oxo-6,8-dioxa-3-azabicyclo[3.2.1]-octane-7-*exo-*carboxylate* ((+)-**25**) and *(1'R,4'R,8'S)-4'-acetyl-10'-(chloromethyl)-8'-(dimethoxymethyl)-9'-methylidene-10'-(2''-nitrophenylthio)-11'-oxatricyclo[6.2.1.0^{2,7}]undec-2'(7')-en-4'-yl (1R,5S,7R)-3-ethyl-2-oxo-6,8-dioxa-3-azatricyclo[3.2.1]octane-7-*exo-*carboxylate* (**26**). The Diels-Alder adduct (-)-**6** (289 mg, 0.59 mmol)[5] was dissolved in anhyd. AcOH (10 ml). After the addition of NBSCl (146 mg, 0.77 mmol), the flask was sealed and heated to 55°C for 6 h. The mixture was poured dropwise into a vigourously stirred sat. aq. soln. of $NaHCO_3$ (150 ml) and CH_2Cl_2 (50 ml). After stirring until CO_2 evolution ceased, the organic layer was collected and washed with sat. aq. soln. of $NaHCO_3$ (30 ml), then with H_2O (30 ml) and brine (30 ml). The combined aq. phases were extracted with CH_2Cl_2 (30 ml, twice). The combined org. extracts were dried ($MgSO_4$) and the solvent was evaporated. The brown residue was adsorbed on Florisil (1g) and separated by FC (30 g, silica gel, EtOAc/light petroleum 17:10 (400 ml), 2:1 (200 ml), 3:1 (200 ml)) giving 157 mg (39%) of (+)-**25** and 49 mg (12%) of **26** (contains ca. 10% of an unknown impurity).

Data of (+)-**25**: yellow solid, m.p. 90-93°C. $[\alpha]_{589}$ = 41.8, $[\alpha]_{577}$ = 44.6, $[\alpha]_{546}$ = 54.3 (c = 1.0, $CHCl_3$). UV λ_{max}: (CH_3CN): 369 (3300), 243 (14700), 205 (16600). IR (KBr) ν: 2920, 2840, 1755, 1720, 1670, 1590, 1510, 1450, 1430, 1330, 1300, 1210, 1150, 1105, 1070, 1010, 950, 870, 850, 780, 730 cm^{-1}. ^{1}H-NMR (250

MHz, $CDCl_3$) δ_H: 8.16 (dd, ^3J = 8.2, ^4J = 1.2); 7.53-7.50 (m, 2 H); 7.30-7.24 (m, 1 H); 5.85 (d, ^3J = 2.1, H-C(5)); 5.51, 5.46 (2s, CH_2=C(9')); 4.96 (br. s, H-C(1')); 4.80, 4.61 (2s, H-C(1), H-C(7)); 4.71 (s, CH-C(8')); 3.57, 3.54 (2s, 2 MeO); 3.65, 3.56 (2d, ^2J = 13.1, CH_2-C(10')); 3.47 (dd, ^2J = 12.1, ^3J = 2.1, H_{exo}-C(4)); 3.45-3.28 (m, CH_2-CH_3); 3.17 (d, ^2J = 12.1, H_{endo}-C(4)); 3.02, 2.82 (2 br. d, ^2J = 18.8, H_2-C(3')); 2.56-2.45, 2.26-2.15, 1.90-1.78 (3 m, H_2-C(5'), H_2-C(6')); 2.14 (s, MeCO); 1.12 (t, ^3J = 7.2, CH_2-CH_3). ^{13}C-NMR (100.61 MHz, $CDCl_3$) δ_C: 204.6 (s, CO); 168.0 (s, COO); 164.8 (s, C(2)); 149.5, 146.8, 141.2, 138.3, 136.5 (5s); 133.4, 127.6, 125.9, 125.1 (4d, ^1J(C,H) = 162-168); 108.6 (t, ^1J(C,H) = 161, CH_2=C(9')); 103.4 (d, ^1J(C,H) = 159, CH-C(8')); 99.8 (d, ^1J(C,H) = 177); 91.7 (s, C(8')); 85.5 (s, C(4')); 83.1 (d, ^1J(C,H) = 167, C(1')); 77.6, 77.1 (2d, ^1J(C,H) = 157, 167); 71.3 (s, C(10')); 57.1, 56.8 (2q, ^1J(C,H) = 142, 2 MeO); 50.8 (t, ^1J(C,H) = 145); 45.3 (t, ^1J(C,H) = 144, CH_2-C(10')); 39.9 (t, ^1J(C,H) = 138); 29.8, 28.6 (2t, ^1J(C,H) = 132, C(3'), C(6')); 23.8 (q, ^1J(C,H) = 129, MeCO); 18.1 (t, ^1J(C,H) = 132, C(5')); 11.7 (q, ^1J(C,H) = 127). CI-MS (NH_3) m/z: 697 (6, $M^{+\bullet}$+19), 696 (26, $M^{+\bullet}$+18), 259 (93), 219 (100), 205 (56), 203 (36), 202 (56), 201 (31), 189 (36), 187 (30), 186 (23), 185 (67), 173 (58), 138 (44), 129 (31), 128 (71), 126 (42), 115 (31), 109 (32), 108 (40), 104 (46). Anal. calc. for $C_{31}H_{35}O_{11}N_2SCl$ (679.15): C 55.83, H 5.19, N 4.12, S 4.72; found: C 55.61, H 5.26, N 4.25, S 4.73.

Data of **26**: yellow solid. IR (KBr) ν: 2920, 1760, 1720, 1670, 1530, 1480, 1430, 1350, 1290, 1210, 1150, 1100, 1070, 1005, 930, 870, 740 cm^{-1}. ^{1}H-NMR (250 MHz, $CDCl_3$) δ_H: 7.87-7.83 (m, 1 H); 7.72-7.68 (m, 1 H); 7.55-7.48 (m, 2 H); 5.73 (d, ^3J = 2.1, H-C(5)); 5.21, 4.81 (2s, CH_2=C(9')); 4.91 (br. s, H-C(1')); 4.55, 4.52 (2 s, H-C(1), H-C(7)); 4.27 (s, CH-C(8')); 3.93, 3.56 (2 d, ^2J = 12.3, $ClCH_2$-C(10')); 3.46 (2s , 2 MeO); 3.47 (dd, ^2J = 12.2, ^3J = 2.1, H_{exo}-C(4)); 3.38-3.16 (m, CH_2-CH_3); 3.12 (d, ^2J = 12.2, H_{endo}-C(4)); 2.73-2.38 (m, H_2-C(3'), H_2-C(6')); 2.12 (s, MeCO); 2.07-1.94, 1.86-1.74 (2m, H_2-C(5')); 1.09 (t, ^3J = 7.2, CH_2-CH_3). ^{13}C-NMR (100.61 MHz, $CDCl_3$) δ_C: 204.2 (s, CO); 167.6 (s, COO); 164.5 (s, C(2)); 155.7, 146.3, 143.5, 136.7, 126.7 (5s); 141.2, 131.1, 130.2, 123.8 (4d, ^1J(C,H) = 164-170); 108.6 (t, ^1J(C,H) = 160, CH_2=C(9')); 104.3 (d, ^1J(C,H) = 160, CH-C(8')); 99.9 (d, ^1J(C,H) = 176); 91.9 (s, C(8')); 86.0 (d, ^1J(C,H) = 169, C(1')); 85.9 (s, C(4')); 77.7, 77.3 (2d, ^1J(C,H) = 156, 167); 65.4 (s, C(10')); 57.7, 56.8 (2q, ^1J(C,H) = 144, 2 MeO); 51.0 (t, ^1J(C,H) = 154, $ClCH_2$-C(10')); 50.7 (t, ^1J(C,H) = 140); 40.0 (t, ^1J(C,H) = 139); 31.1, 25.5 (2t, ^1J(C,H) = 131, C(3'), C(6')); 24.1 (q, ^1J(C,H) = 128, MeCO); 18.2 (t, ^1J(C,H) = 131, C(5')); 11.6 (q, ^1J(C,H) = 126). CI-MS (NH_3) m/z: 696 (1, $M^{+\bullet}$+19), 202 (2), 85 (4), 75 (100, $[CH(OMe)_2]^+$).

(2R,5S,12R)-2-Acetyl-1,2,3,4,5,12-hexahydro-10-methoxy-5-(dimethoxymethyl)-5,12-epoxynaphthacen-2-yl acetate (**28**). A mixture of (-)-**21** (15 mg, 0.036 mmol), pyridine (1 ml), Ac_2O (0.2 ml) and DMAP (1 mg) was stirred at 20°C for 30 h. CH_2Cl_2 (20 ml) was added and the soln. washed with 2 N H_2SO_4 (10 ml, twice), sat. aq. soln. of $NaHCO_3$ (10 ml, twice), and with brine (10 ml). After drying ($MgSO_4$), the solvent was evaporated and the residue purified by filtration on a short pad of silica gel (EtOAc/light petroleum 2:3) giving 12 mg (74%), white solid, m.p. 72-74°C. IR (KBr) ν: 2920, 2820, 1725, 1710, 1595, 1505, 1460, 1430, 1360, 1260, 1230, 1190, 1070, 1015 cm^{-1}. ^{1}H-NMR (250 MHz, $CDCl_3$) δ_H: 7.92 (s, H-C(11)); 7.64 (s, H-C(6)); 7.34-7.31 (m, H-C(7), H-C(8)); 6.83-6.80 (m, H-C(9)); 5.55 (br. s, H-C(12)); 5.05 (s, CH-C(5)); 3.97 (s, CH_3O-C(10)); 3.72, 3.67 (2s, 2 MeO); 3.03 (br. ddd, ^2J = 18.2, ^5J = 3.2, ^5J = 3.0, H_{exo}-C(1)); 2.61 (br. dm, ^2J = 18.5, H_{exo}-C(4)); 2.40 (br. d, ^2J = 18.2, H_{endo}-C(1)); 2.02 (s, COMe); 2.10-1.97 (m, H_{endo}-C(4), H_{exo}-C(3)); 1.88-1.74 (m, H_{endo}-C(3)); 0.86 (s, AcO). CI-MS (MH_3) m/z: 472 (3, $M^{+\bullet}$+20), 471 (12, $M^{+\bullet}$+19), 470 (22, $M^{+\bullet}$+18), 422 (6), 421 (14, $[M\text{-}OCH_3]^+$), 223 (4), 85 (4), 83 (4), 76 (3), 75 (100, $[CH(OMe)_2]^+$).

(2R)-2-Acetyl-5-formyl-1,2,3,4-tetrahydro-10-methoxynaphthacene-2,12-diyl diacetate ((+)-**23**) and *(2R)-2-acetyl-1,2,3,4-tetrahydro-10-methoxynaphthacene-2,5-diyl diacetate* ((+)-**24**). $(CH_3)_3SiOSO_2CF_3$ (28 µl, 0.16 mmol) was added to a stirred soln. of (-)-**21** (16 mg, 0.039 mmol) in anhyd. CH_2Cl_2 (2.5 ml) cooled to -8°C. After stirring for 5 min at -8°C, the violet soln. was poured into a vigorously stirred mixture of EtOAc (20 ml) and sat. aq. soln. of $NaHCO_3$ (20 ml) cooled to 0°C. After 5 min, the org. phase was collected and the aq. phase extracted with EtOAc (10 ml). The combined org. extracts were washed with brine (10 ml, twice) and dried (Na_2SO_4). The solvent was evaporated and the residue was dissolved in pyridine (1 ml) at 0°C. Ac_2O (0.3 ml) was added and the temperature was allowed to increase to 20°C in 1 h. After stirring at 20°C for 14 h, EtOAc (20 ml) was added and the soln. washed with 2 N H_2SO_4 (20 ml, twice), sat. aq. soln. of $NaHCO_3$ (20 ml, twice) and brine (20 ml). After drying ($MgSO_4$), the solvent was evaporated to dryness and the orange-yellow residue was separated by FC (7 g, CH_2Cl_2/EtOAc 95:5) giving 2.3 mg (14%) of (+)-**24** and 8.5 mg (48%) of (+)-**23**. The same procedure was applied to acetate **28** (11 mg, 24 µmol) giving 5.8 mg (59%) of (+)-**23** and 1.6 mg (17%) of (+)-**24**.

Data of (+)-**23**: yellow crystals, m.p. 209-210°C (EtOAc/hexane). $[\alpha]_{589}$ = 5.1, $[\alpha]_{577}$ = 5.2, $[\alpha]_{546}$ = 4.3 (c = 0.6, $CHCl_3$). UV (CH_3CN) λ_{max}: 410 (5600), 269 (48800), 246 (51700). IR (KBr) ν: 2920, 1760, 1730, 1675, 1605, 1550, 1520, 1450, 1430, 1360, 1275, 1230, 1185, 1135, 1100, 1080, 1010, 880, 785, 735, 610 cm^{-1}. ^{1}H-NMR (250 MHz, $CDCl_3$) δ_H: 11.11 (s, CHO); 9.44 (s, H-C(11)); 8.75 (s, H-C(6)); 7.63 (d, ^3J = 8.7, H-C(7)); 7.44 (dd, ^3J = 8.7, 7.3, H-C(8)); 6.78 (d, ^3J = 7.3, H-C(9)); 4.08 (s, CH_3O-C(10)); 3.56-3.30 (br. m, H_2-C(1), H_2-C(4)); 2.61 (s, AcO-C(12)); 2.49-2.38, 2.16-2.09 (2 br. m, H_2-C(3)); 2.26 (s, $COCH_3$); 2.05 (s, AcO-C(2)). ^{13}C-NMR (100.61 MHz, $CDCl_3$) δ_C: 205.4 (s, CO-C(2)); 192.3 (d, ^1J(C,H) = 174, CHO); 170.7, 168.7 (2 s, 2 COO); 155.3 (s, C(10)); 149.8, 141.8, 134.2, 129.0, 125.7, 125.0, 123.9, 122.5 (8s); 126.8, 123.1, 121.0, 115.1, 102.6 (5d, ^1J(C,H) = 158-164); 87.2 (s, C(2)); 55.6 (q, ^1J(C,H) = 143, CH_3O-C(10)); 29.4, 28.6 (2t, ^1J(C,H) = 130, C(1), C(4)); 23.7 (q, ^1J(C,H) = 128, COMe); 23.2 (t, ^1J(C,H) = 131, C(3)); 21.0, 20.8 (2q, ^1J(C,H) = 131, 2 AcO). CI-MS (NH_3) m/z: 464 (51, $M^{+\bullet}$+18), 449 (21, $M^{+\bullet}$+1), 448 (100, $M^{+\bullet}$), 406 (33, [M-CH_3CO]$^+$), 346 (57), 337 (33), 303 (59), 215 (24), 75 (30). Anal. calc. for $C_{24}H_{26}O_7$ (448.48): C 69.63, H 5.39; found: C 69.47, H 5.46.

Data of (+)-**24**: white solid, m.p. 91-93°C. $[\alpha]_{589}$ = 1.9, $[\alpha]_{577}$ = 2.6, $[\alpha]_{546}$ = 4.5 (c = 0.15, $CHCl_3$). UV (CH_3CN) λ_{max}: 397 (3100), 377 (4300), 359 (3400), 255 (50000), 226 (12400), 197 (18900). IR (KBr) ν: 2920, 2840, 1760, 1730, 1620, 1550, 1530, 1455, 1425, 1360, 1350, 1270, 1230, 1195, 1165, 1095, 1050, 780, 730 cm^{-1}. ^{1}H-NMR (360 MHz, $CDCl_3$) δ_H: 8.77 (s, H-C(11)); 8.20 (s, H-C(6)); 7.74 (s, H-C(12)); 7.56 (d, ^3J = 8.5, H-C(7)); 7.36 (dd, ^3J = 8.5, 7.3, H-C(8)); 6.73 (d, ^3J =7.3, H-C(9)); 4.08 (s, CH_3O-C(10)); 3.53, 3.45 (2 br. d, ^2J = 17.8, H_2-C(1)); 2.95-2.83 (br. m, H_2-C(4)); 2.58 (s, AcO-C(5)); 2.48-2.40, 2.24-2.08 (2 br. m, H_2-C(3)); 2.25 (s, $COCH_3$); 2.02 (s, AcO-C(2)). ^{13}C-NMR (100.61 MHz, $CDCl_3$) δ_C: 206.1 (s, CO); 170.7, 169.0 (2 s, 2 COO); 155.4 (s, C(10)); 143.1, 132.6, 131.0, 130.7, 125.2, 125.0, 124.5 (7s); 126.2, 125.6, 120.7, 120.6, 102.6 (5d, ^1J(C,H) = 159-163); 101.8 (d, ^1J(C,H) = 158, C(12)); 84.1 (s, C(2)); 55.5 (q, ^1J(C,H) = 144, CH_3O); 35.7, 28.2 (2 t, ^1J(C,H) = 131, C(1), C(4)); 24.0 (q, ^1J(C,H) = 128, $COCH_3$); 20.9, 20.8 (2 q, 2 AcO); 20.5 (t, ^1J(C,H) = 130, C(3)). CI-MS m/z: 421 (23, $M^{+\bullet}$+1), 420 (39, $M^{+\bullet}$), 361 (21), 360 (30, [M-CH_3COOH]$^+$), 319 (48), 318 (100), 275 (22), 97 (22), 91 (26), 85 (44), 83 (67). Anal. calc. for $C_{25}H_{24}O_6$ (420.47): C 71.42, H 5.75; found: C 71.51, H 5.67.

(2R)-2-Acetyl-1,2,3,4-tetrahydro-5-(hydroxymethyl)-10-methoxynaphthacene-2,12-diyl diacetate (**29**). A soln. (0.8 ml) made up of $NaBH_3CN$ (17.7 mg) and MeOH (4 ml) was added to a soln. of (+)-**23** (22 mg, 0.049 mmol) in $CHCl_3$ (0.8 ml). AcOH (10 µl) was then added and the mixture was stirred at 20°C for 6 h. EtOAc (20 ml) was added and the soln. washed with sat. aq. soln. of $NaHCO_3$ (20 ml, 3 times), brine (20 ml). After drying ($MgSO_4$), the solvent was evaporated and the residue purified by FC (CH_2Cl_2/EtOAc 4:1) giving a yellowish oil. IR (KBr) ν: 3440, 2920, 1760, 1730, 1620, 1550, 1430, 1360, 1230, 1190, 1100, 1070, 1010, 880, 780 cm^{-1}. ^{1}H-NMR (250 MHz, $CDCl_3$) δ_H: 8.71 (br. s, H-C(6), H-C(11)); 7.60 (d, ^3J = 8.6, H-C(7)); 7.38 (dd, ^3J = 8.6, 7.3, H-C(8)); 6.75 (d, ^3J = 7.3, H-C(9)); 5.28 (br. s, CH_2OH); 4.06 (s, CH_3O-C(10)); 3.39-3.19 (br. m, H_2-C(1), H_2-C(4)); 2.58 (s, AcO-C(12)); 2.56-2.32, 2.17-2.05 (2 br. m, H_2-C(3)); 2.25 (s, $COCH_3$); 2.04 (s, AcO-C(2)); 1.74 (s, CH_2-O*H*). CI-MS (NH_3) m/z: 451 (12, $M^{+\bullet}$+1), 450 (22, $M^{+\bullet}$), 408 (15), 391 (12), 348 (49), 219 (11), 111 (16), 85 (70), 84 (27), 83 (48), 71 (100).

(2R)-5-(Acetoxymethyl)-2-acetyl-1,2,3,4-tetrahydro-10-methoxynaphthacene-2,12-diyl diacetate ((-)-**30**). Ac_2O (0.4 ml) was added to a soln. of **29** (obtained above) in pyridine (0.8 ml) and cooled to 0°C. After stirring at 0°C for 30 min, the mixture was allowed to stand at 20°C for 3 h. EtOAc (30 ml) was added and the soln. washed with 2 N H_2SO_4 (20 ml, twice), sat. aq. soln. of $NaHCO_3$ (20 ml, twice), and brine (20 ml). After drying ($MgSO_4$) the solvent was evaporated and the residue filtered through a pad of silica gel (EtOAc/CH_2Cl_2 1:12) and crystallized from EtOAc/hexane giving 16 mg (66%) of yellowish crystals, m.p. 176-177°C. $[\alpha]_{589}$ = -3.7, $[\alpha]_{577}$ = -3.2, $[\alpha]_{546}$ = -3.9 (c = 0.7, $CHCl_3$). UV (CH_3CN) λ_{max}: 401 (sh), 282 (6900), 364 (sh), 262 (99500), 242 (39100), 226 (17900), 201 (28400). IR (KBr) ν: 2930, 1760, 1730, 1670, 1550, 1450, 1430, 1365, 1235, 1190, 1135, 1100, 1080, 1020, 950, 880, 780, 740, 610 cm^{-1}. ^{1}H-NMR (250 MHz, $CDCl_3$) δ_H: 8.71 (s, H-C(11)); 8.57 (s, H-C(6)); 7.61 (d, ^3J = 8.6, H-C(7)); 7.40 (dd, ^3J = 8.6, 7.3, H-C(8)); 6.75 (d, ^3J = 7.3, H-C(9)); 5.76 (br. s, CH_2OAc); 4.07 (s, CH_3O); 3.41-3.19 (br. m, H_2-C(1), H-C(4)); 2.59 (s, AcO-C(12)); 2.52-2.40, 2.18-2.12 (2 br. m, H_2-C(3)); 2.25 (s, $COCH_3$); 2.11 (s, *Ac*O-CH_2-C(5)); 2.04 (s, AcO-C(2)). ^{13}C-NMR (100.61 MHz, $CDCl_3$) δ_C: 205.7 (s, CO); 171.3, 170.7, 169.1 (3 s, 3 COO); 155.3 (s, C(10)); 145.9, 134.4, 133.0, 130.6, 125.6, 124.8, 124.0, 122.1 (8s); 126.0, 122.1, 120.7, 114.8, 102.1 (5d, ^1J(C,H) = 158-164); 83.2 (s, C(2)); 59.4 (q, ^1J(C,H) = 147, CH_3O); 29.7, 28.9 (2t, ^1J(C,H) = 131, 136, C(1), C(4)); 23.9 (q, ^1J(C,H) = 128, $COCH_3$); 23.2 (t, ^1J(C,H) = 129, C(3)); 21.1, 21.0, 20.9 (3q, ^1J(C,H) = 130, 3 AcO). CI-MS (NH_3) m/z: 493 (26, $M^{+\bullet}$+1), 492 (64, $M^{+\bullet}$), 450 (34), 391 (44), 390, (100), 287 (25), 111 (21), 99 (27), 85 (55), 84 (23), 83 (39), 71 (99). Anal. calc. for $C_{28}H_{28}O_8$ (492.53): C 68.28, H 5.73; found: C 68.14; H 5.85.

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