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Article

Total Synthesis of Bisbibenzylic Compounds Isolated From Bryophytes

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A síntese de três novas perrotetinas isoladas de *Pellia epiphylla* é descrita. A comparação do material sintético e natural pôde confirmar a existência de apenas 14'-Hidroxi-perrotetinas E entre os produtos isolados de *Pellia epiphylla*.

As a part of a plan for the preparation of Bryophyte constituents, the synthesis of three new perrottetins isolated from *Pellia epiphylla* was undertaken. Accordingly, efficient and expeditious syntheses of new perrottetins are described. Comparison between the natural and synthetic material could only confirm the existence of 14'- Hydroxyperrottetin E among the products isolated from *Pellia epiphylla*, being the structures of the other two isolated compounds different from the proposed ones.

Keywords: Pellia epiphylla, *liverwort, synthesis, perrottetins*

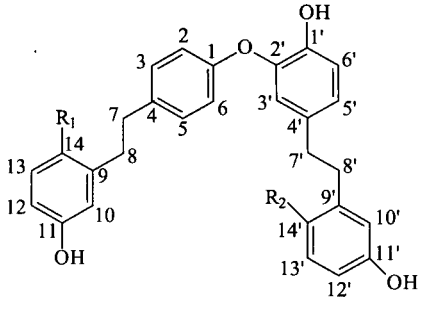
Introduction

During our work on the synthesis of Bryophyte constituents[1], we devoted chiefly to the preparation of bisbibenzyl derivatives. In particular , perrottetins [*e.g.* Perrottetin E (1)], a type of bisbibenzylethers with potential biological activity[2], belong to a kind of natural compounds that has only been found in Moos[3]. Cullmann *et al.*[4] isolated three new bisbibenzylethers from *Pellia Epiphylla,* a liverwort found in Central Europe and North America. According to these authors the bisbibenzylethers isolated were 14'-Hydroxyperrottetin E (2), 14-Hydroxyperrottetin E (3), and 14,14'-Dihydroxyperrottetin E (4) (see Fig. 1). We now report the efficient synthesis of these molecules [(2), (3), and (4)], as a way to corroborate the proposed structures and to obtain enough quantity for biological screening.

Results and Discussion

All the target molecules present the same diphenylether structure as the central core, and two different appendages that vary according to the final compound. This feature determined the general synthetic scheme: formation at the beginning of the ether linkage, via an aromatic nucleophilic substitution, and then coupling of the two appendages using Wittig reactions in sequential form (see Scheme 1).

In this way, the synthesis of 14'-Hydroxyperrottetin E started by a S_NAr reaction between 4-Chloro-3-nitrobenzaldehyde (5) and Methyl 3-Hydroxy-4-methoxybenzoate

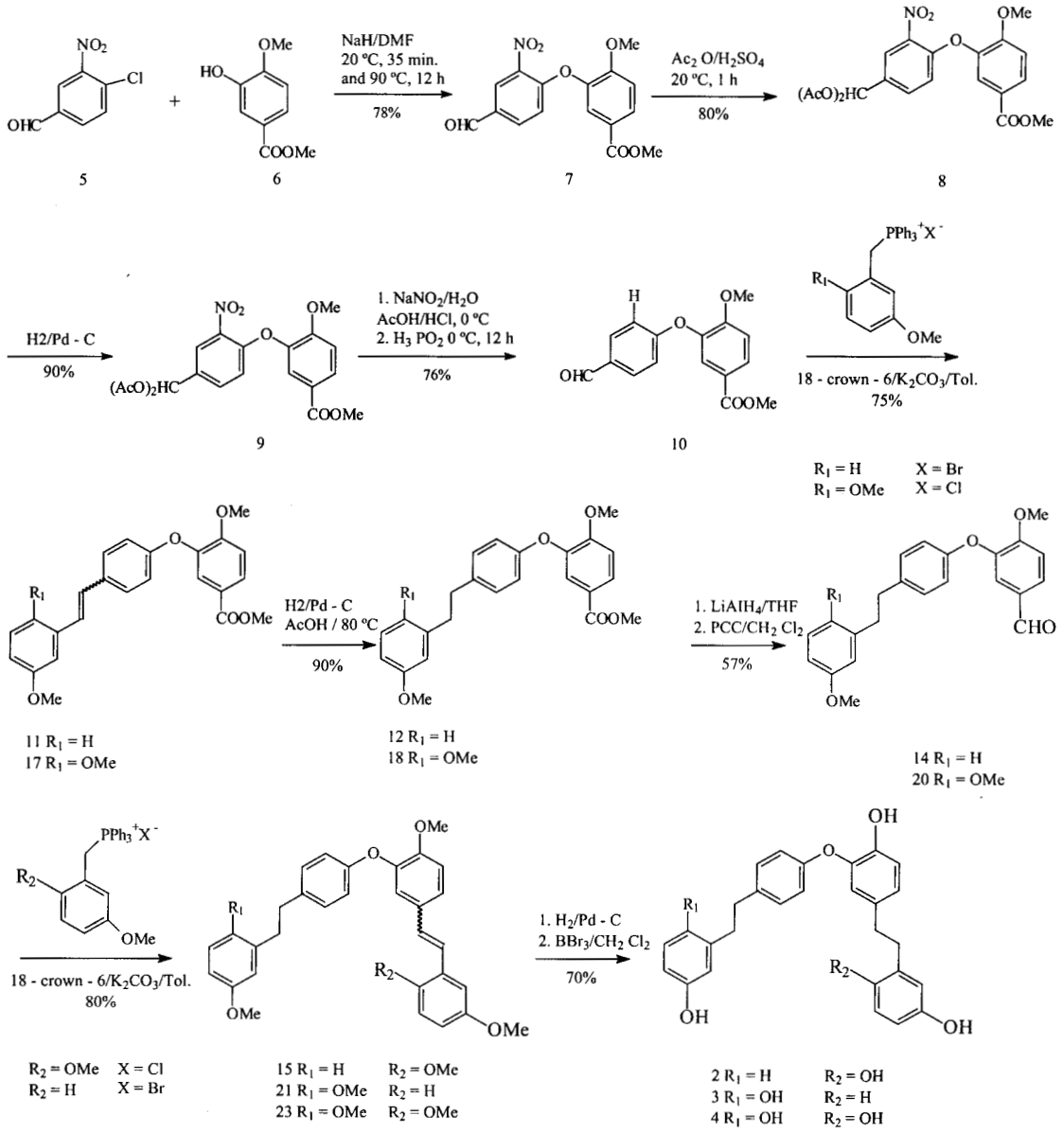


1 R_1 = H R_2 = H
2 R_1 = H R_2 = OH
3 R_1 = OH R_2 = H
4 R_1 = 0H R_2 = OH

Figure 1. Perrottetin E (1) and proposed structures of three new perrottetins from *Pellia Epiphylla* (2), (3), and (4).

(6), obtaining the diphenylether (7). After protection of the carbonyl group as bisacyl (8), the nitro group was reduced to the corresponding amine (9) through catalytic hydrogenation, and a further diazotation/deamination sequence using hypophosphorous acid afforded the diphenylether (10). This ether contains the substitution pattern of the target perrottetins. Moreover, the presence of aldehyde and ester functionalities allows for the Wittig reactions to be run sequentially. The first Wittig reaction, performed under Boden conditions[5] between aldehyde (10) and the ylide derived from (3-Methoxybenzyl)triphenylphosphonium bromide, gave stilbene (11) as an inseparable mixture of Z/E isomers. The crude mixture was hydrogenated with H_2 over Pd-C to give the substituted bibenzyl (12). To build the second bibenzylic portion of the molecule, conversion of the ester group into aldehyde was necessary, in order to perform another Wittig reaction. The ester (12) was thus reduced to alcohol (13) and further oxidized to the aldehyde (14). Such aldehyde was reacted with the ylide derived from (2,5-Dimethoxybenzyl)triphenylphosphonium chloride to give the stilbene (15) as a mixture of Z/E isomers, which was rapidly hydrogenated to (16) and then deprotected using boron tribromide at low temperature to afford 14'-Hydroxyperrottetin E (2).

The synthesis of 14-Hydroxyperrottetin E (3) was based on the same synthetic idea. Starting with diphenylether (10), a Wittig reaction with (2,5-Dimethoxybenzyl)triphenyl phosphonium chloride was performed to obtain the stilbene (17). Further hydrogenation to (18), reduction of the ester group to alcohol (19) and subsequent



Scheme 1. Preparation of compounds (2), (3) and (4).

oxidation afforded the aldehyde (20) , which was reacted with the ylide derived from (3-Methoxybenzyl)triphenylphosphonium bromide in a Wittig reaction to obtain the stilbene (21) as a mixture of Z/ E isomers. Catalytic hydrogenation to (22) and further deprotection gave 14-Hydroxyperrottetin E (3).

For the synthesis of 14,14'-Dihydroxyperrottetin E (4), aldehyde (20) from the previous synthesis was used and a Wittig reaction was performed again using the ylide derived from (2,5-Dimethoxybenzyl)triphenylphosphonium chloride. Stilbene (23) was obtained, again as a mixture of Z/E isomers, which was hydrogenated to (24) over Pd-C as catalyst and further deprotected with Boron tribromide at low temperature to give 14,14'-Dihydroxyperrottetin E (4).

Once the perrottetins were prepared, a comparison between the ^{1}H-NMR spectra from the authentic and synthetic samples was undertaken. Table 1 and Fig. 2 show the ^{1}H-NMR spectra of both natural and synthetic 14-Hydroxyperrottetin E. It can be noticed that there is no coincidence among the signals in the spectra. In addition, no coincidence was observed between the ^{1}H-NMR spectra of both natural and synthetic 14'-Hydroxyperrottetin E (Table 2 and Fig. 3). Careful inspection of Table 1 and Fig. 2, and Table 2 and Fig. 3 shows that it really exists coincidence between the data corresponding to natural 14-Hydroxyperrottetin E, isolated by Cullmann, and our synthetic 14'-Hydroxy-perrottetin E.

Table 3 and Fig. 4 show the ^{1}H-NMR spectra of natural and synthetic 14,14'-Dihydroxyperrottetin E. There is no coincidence either between the spectra of both products.

Since the synthetic products have been obtained through a logical sequence of reactions, we are able to state that there was a misinterpretation of the spectroscopic data

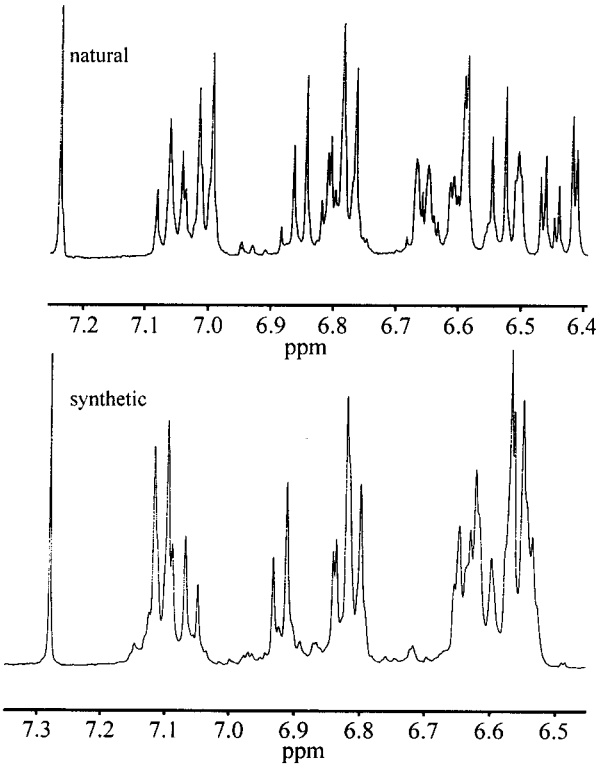


Figure 2. Aromatic portion of the ^{1}H-NMR spectra of natural and synthetic 14- Hydroxyperrottetin E (3) (taken on a Bruker AM 400, in $CDCl_3$).

Table 1. ^{1}H-NMR spectra of natural and synthetic14- Hydroxyperrottetin E (3).

14- Hydroxyperrottetin E natural[4], ^{1}H-NMR ($CDCl_3$/ TMS), δ, *J* (Hz)	14-Hydroxyperrottetin E synthetic, ^{1}H-NMR ($CDCl_3$/ TMS), δ, *J*(Hz)
7. 06 (dd, J_1 = 7.8, J_2 = 7.8; 1H)	7.17 (d, *J* = 8.4, 2H)
7.01 (d, *J* = 8.5, 2H)	7.04 (t, *J* = 7.5, 1H)
6.85 (d, *J*= 8.1, 1H)	6.89-6.87 (not resolved, 2H)
6.81 (dd, J_1= 2.0, J_2 = 8.2, 1H)	6.77 (d, *J* = 8.4, 2H)
6.78 (d, *J* = 8.5, 2H)	6.73-6.72 (not resolved, 1H)
6.65 (not resolved, 1H)	6.68 (d, *J* = 8,4, 1H)
6.60 (not resolved, 2H)	6.65-6.61 (m, 4H)
6.54 (d, *J* = 8.5, 1H)	6.51 (dd, J_1 = 8.6, J_2 = 3.0, 1H)
6.50 (not resolved, 1H)	
6.45 (dd, J_1 = 2.8, J_2 = 8.5, 1H)	
6.42 (d, *J* = 2.8, 1H)	
2.81 (m, 4H)	2.84 (s, br, 4H)
2.78 (s, 4H)	2.78 (s, 4H)

leading to a wrong assignment of the structures of the isolated compounds. We could only confirm the presence of 14'-Hydroxyperrottetin E in the products isolated by Cullmann from *Pellia Epiphyllia.*

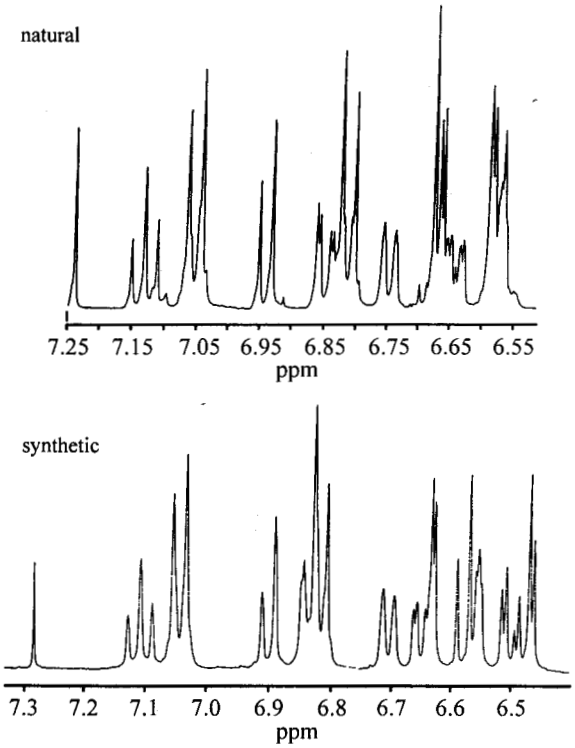


Figure 3. Aromatic portion of the ^{1}H-NMR spectra of natural and synthetic 14'- Hydroxyperrottetin E (2) (taken on a Bruker AM 400, in $CDCl_3$).

According to more recent spectroscopic data[6], the structures of the other two isolated perrottetins were revised

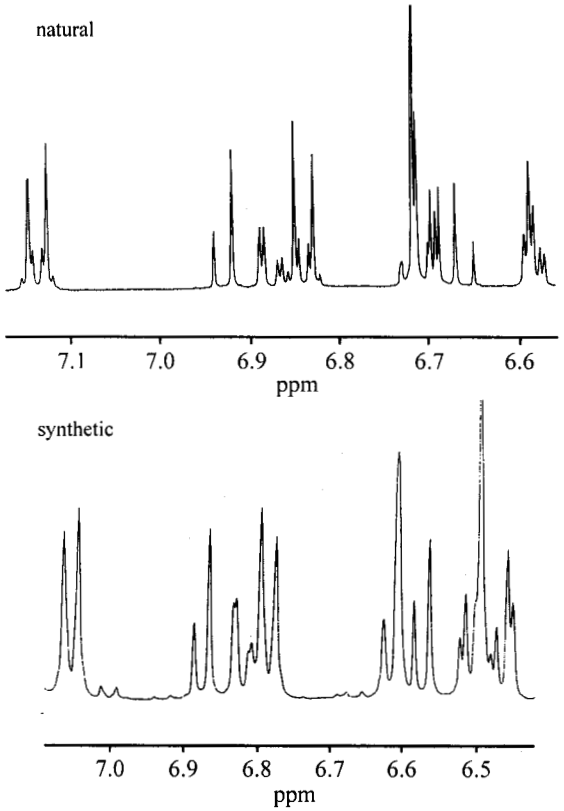
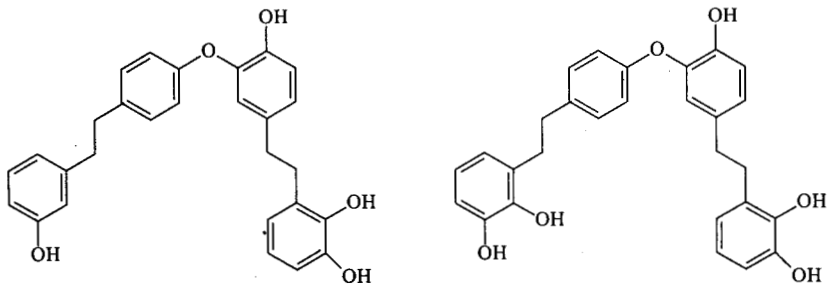


Figure 4. Aromatic portion of the ^{1}H-NMR spectra of natural and synthetic 14, 14'- Dihydroxyperrottetin E (4) (taken on a Bruker AM 400, in $CDCl_3$).

Table 2. ^{1}H-NMR spectra of natural and synthetic 14'- Hydroxyperrottetin E (2).

14'-Hydroxyperrottetin E natural[4], ^{1}H-NMR ($CDCl_3$/ TMS), δ, *J*(Hz)	14'-Hydroxyperrottetin E synthetic, ^{1}H-NMR ($CDCl_3$/ TMS), δ, *J*(Hz)
7.13 (dd, J_1 = 8. 3, J_2 = 8.3; 1H)	7.10 (t, J = 7.8, 1H)
7.05 (d, J = 8.3, 2H)	7.04 (d, J = 8.5, 2H)
6.94 (d, J= 8.0, 1H)	6.89 (d, J = 8.1, 1H)
6.85 (dd, J_1= 1.9, J_2 = 8.5, 1H)	6.83 (dd, J_1= 2.0, J_2 = 8.2
6.81 (d, J = 8.3, 2H)	6.80 (d, J = 8.5, 2H)
6.74 (d, J = 7.5, 1H)	6.70 (d, J = 7.5, 1H)
6.63-6.70 (not resolved, 3H)	6.60 (dd, J_1 = 2.2, J_2 = 8.2, 1H)
6.55-6.59 (not resolved, 3H, 1H)	6.62 (d, J = 2.0, 1H)
	6.57 (d, J = 8.5, 1H)
	6.55-6.54 (m, 1H)
	6.49 (dd, J_1 = 2.8, J_2 = 8.5, 1H)
	6.46 (d, J = 2.8, 1H)
2.85 (s, 4H)	2.84 (s, br,4H)
2.78 (m, 4H)	2.74 (s, 4H)



3a 4a

Figure 5. Revised structure of perrottetins from *Pellia Epiphylla*.

Table 3. : ^{1}H-NMR spectra of natural and synthetic 14, 14'- Dihydroxyperrottetin E (4).

14'- Dihydroxyperrottetin E natural[4], ^{1}H-NMR ($CDCl_3$/ TMS), δ, *J*(Hz)	14'-Hydroxyperrottetin E synthetic, ^{1}H-NMR ($CDCl_3$/ TMS), δ, *J*(Hz)
7.14 (d, *J* = 8.6, 2H)	7.05 (d, *J* = 8.4, 1H)
6.93 (d, *J* = 8.1, 1H)	6.87 (d *J* = 8.1, 1H)
6.88 (dd, J_1 = 2.0, J_2 = 8.2, 1H)	6.82 (dd, J_1 = 1.6, J_2 = 8.1, 1H)
6.84 (d, *J* = 8.6, 2H)	6.78 (d, *J* = 8.4, 2H)
6.72 (not resolved, 2H)	6.62-6.60 (not resolved, 2H)
6.71 (not resolved, 1H)	6.57 (d, *J* = 8.4, 1H)
6.69 (dd, J_1 =1.4, J_2 = 3.4, 1H)	6.51 (d, *J* = 3.0, 1H)
6.59 (d, *J* = 2.1, 1H)	6.49 (not resolved, 2H)
6.58 (dd, J_1 = 2.0, J_2 = 5.1, 1H)	6.46 (dd, J_1 = 3.0, J_2 = 8.8, 1H)
2.90 (s, 4H)	2.82 (s, br, 4H)
2.81 (m, 4H)	2.73 (s, 4H)

from (3) and (4) to (3a) and (4a) respectively (Fig. 5). The revised structures were confirmed by independent syntheses, which will be the subject of an incoming report.

Experimental

Melting points were determined using a Gallenkamp apparatus and are uncorrected. IR spectra were recorded on a Acculab 8 Beckman spectrometer coupled to a PC and are reported as (max (cm^{-1}). ^{1}H-NMR and ^{13}C-NMR spectra were recorded on a Bruker AM 400 (400 MHz) spectrometer using $CDCl_3$ as solvent and TMS as internal standard and are reported in δ values. Mass spectra were taken on a MAT 311 Finnigan at an ionizing potential of 70 eV. Elemental analyses, carried out by the Institute of Organic Chemistry of the Universitat des Saarlandes (Germany), gave satisfactory results: C, H ± 0.3. Column chromatography was performed with Kieselgel silica gel (0.063-0.2 mm) from J.T. Baker. All solvents were purified and dried before use using standard methods. The phosphonium salts (3-Methoxybenzyl)triphenylphosphonium bromide and (2,5-Dimethoxybenzyl)-triphenylphosphonium chloride were prepared acording to literature procedures[7].

Wittig reaction; general procedure

The corresponding diphenylether (4.2 mmol) and phosphonium salt (4.3 mmol) were dissolved in the minimum amount of toluene, and solid potassium carbonate (1.2 g, 8.6 mmol) and a tip of spatula of 18:crown:6 ether were added at r.t.. The reaction mixture was then heated to reflux for 18 h. The solvent was evaporated under vacuum and the residue purified by column chromatography on silica gel.

Hydrogenation; general procedure

The corresponding stilbene (2.5 mmol) was dissolved in acetic acid (20 mL) and hydrogenated over 5% Pd/C

(0.2 g) at 5 atm and 80 °C for 12 h. The catalyst was filtered off and the solvent removed under vacuum to give the crude compound, which was purified by column chromatography (silica gel / CH_2Cl_2).

Deprotection with Boron tribromide; general procedure

To a solution of protected perrottetin (0.5 mmol) in dry CH_2Cl_2 (20 mL) was added dropwise a solution of boron tribromide in CH_2Cl_2 (1 M solution, corresponding to a tenfold excess for each group to deprotect) at -78 °C under a N_2 atmosphere. After 3 h of vigorous stirring the mixture was allowed to warm up to r.t. and poured on ice-water. The layers were separated and the aqueous phase was extracted with ether (2 x 30 mL). The combined organic layer was washed with saturated solution of $NaHCO_3$ (2 x 30 mL) and dried over $MgSO_4$. The solvent was removed under vacuum and the residue purified by column chromatography (silica/ether).

4-Formyl-2'-methoxy-5'-methoxycarbonyl-2-nitrodiphenylether (7)

To a stirred suspension of sodium hydride (4 g, 100 mmol, 60% in mineral oil) in dry DMF (50 mL) was added dropwise a solution of Methyl 3-hydroxy-4-methoxybenzoate (6) (18,2 g, 100 mmol) in dry DMF (100 mL) under N_2. After stirring for 10 min the mixture was cooled down to 0 °C and a solution of 4-Chloro-3-nitrobenzaldehyde (5) (18,6 g, 100 mmol) in dry DMF (100 mL) was added dropwise. The mixture was allowed to warm up to r.t. and the stirring was continued for 2 more h. The solvent was evaporated under vacuum and the residue poured in CH_2Cl_2 (500 mL). The organic layer was washed with aqueous NaOH (2 M solution, 3 x 100 mL), aqueous HCl (1 M solution, 2 x 100 mL), dried over $MgSO_4$, and the solvent was evaporated under vacuum. The resulting residue was purified by recrystallization from chlroform/ethanol (1:2), affording (7) as yellow needles; yield: 25.8 g (78%); mp 134-136 °C.

^{1}H-NMR: δ = 9.97 (s, 1H, CHO), 8.47 (d, J = 1.9 Hz, 1H, ArH), 8.02 (dd, J_1 = 8.7 Hz, J_2 = 2.0 Hz, 1H, ArH), 7.96 (dd, J_1 = 8.6 Hz, J_2 = 1.9 Hz, 1H, ArH), 7.86 (d, J = 2.1 Hz; 1H, ArH), 7.09 (d, J = 8.7 Hz, 1H, ArH), 6.89 (d, J = 8.7 Hz, 1H, ArH), 3.90 (s, 3H, $COOCH_3$), 3.84 (s, 3H, OCH_3).

^{13}C-NMR: δ = 188.61 (CHO), 165.69 ($\underline{C}OOCH_3$), 155.70, 155.04, 151.47, 139.78, 134.03, 130.59, 129.51, 127.80, 123.91, 123.72, 112.50, 56.18 (OCH_3), 52.21 ($COO\underline{C}H_3$).

IR (KBr): ν (cm^{-1}) = 2350,1715 ($COOCH_3$), 1305 (CHO), 1625, 1535 (NO_2), 1515, 1445, 1350 (NO_2)

MS: *m/z* (%) = 331 [M^+] (4), 181 (16), 125 (3), 121 (3), 42 (100)

4-Diacetoxymethyl-2'- methoxy-5'-methoxycarbonyl-2-nitrodiphenylether (8)

Compound (7) (33.1 g, 100 mmol) was taken in acetic anhydride (400 mL), and concentrated H_2SO_4 (2 mL) was added dropwise under vigorous stirring. The mixture was stirred 5 h at r.t. and then poured onto ice-water (250 mL). Crude compound (8) precipitated and was filtered under vacuum. The purification was performed by recrystallization from ethanol to give (8) as white needles; yield: 34.7 g (80%); mp 114-115 °C.

^{1}H-NMR: δ = 8.15 (d, J = 2.2 Hz, 1H, ArH), 7.96 (dd, J_1 = 8.7 Hz, J_2 = 2.1 Hz, 1H, ArH), 7.77 (d, J = 2.1 Hz, 1H, ArH), 7.66 (s, 1H, -O-CH-O), 7.59 (dd, J_1 = 8.7 Hz, J_2 = 2.2 Hz, 1H, ArH), 7.07 (d, J = 8.7 Hz, 1H, ArH), 6.82 (d, J = 8.6 Hz, 1H, ArH), 3.88 (s, 3H, $COOCH_3$), 3.86 (s, 3H, OCH_3), 2.15 (s, 3H, CH_3COO).

^{13}C-NMR: δ = 168.62 ($CH_3\underline{C}OO$), 165.83 ($\underline{C}OOCH_3$), 155.21, 152.06, 142.50, 139.85, 132.54, 130.31, 128.87, 124.42, 123.49, 123.25, 118.03, 112.41, 88.25 (-O-CH-O), 56.25 (OCH_3), 52.16 ($COO\underline{C}H_3$), 20.77 ($\underline{C}H_3O$).

IR (KBr): ν (cm^{-1}) = 1770 (CH_3COO), 1730 ($COOCH_3$), 1635, 1615, 1585, 1540 (NO_2), 1515, 1445, 1430, 1375, 1350 (NO_2), 1295

MS: *m/z* (%) = 433 [M^+] (8), 301 (8), 300 (26), 182 (12), 181 (79), 153 (6), 121 (19), 119 (6), 42 (100).

2-Amino-4-diacetoxymethyl-2'-methoxy-5'-methoxycarbonyldiphenylether (9)

A solution of (8) (20.0 g, 46.1 mmol) in methanol (600 mL) was hydrogenated over 5% Pd/C (3.0 g) at 5 atm and 50 °C during 1 h. The catalyst was filtered and the filtrate evaporated under vacuum to give a residue, which was purified by recrystallization from ethanol affording (9) as white needles; yield: 16.6 g (90%); mp 124-126 °C.

^{1}H-NMR: δ = 7.84 (dd, J_1 = 8.5 Hz, J_2 = 2.1 Hz, 1H, ArH), 7.59 (d, J = 2.1 Hz, 1H, ArH), 7.58 (s, 1H, -O-CH-O-), 7.01 (d, J = 8.6 Hz; 1H, ArH), 6.97 (d, J = 2.0 Hz, 1H, ArH), 6.8 (dd, J_1 = 8.3 Hz, J_2 = 2.0 Hz, 1H, ArH), 6.67 (d, J = 8.3 Hz, 1H, ArH), 4.03 (s, br, 2H, NH2), 3.90 (s, 3H, $COOCH_3$), 3.84 (s, 3H, OCH_3), 2.12 (s, 6H, CH_3COO).

^{13}C-NMR: δ = 168.81 ($CH_3\underline{C}OO$), 166.28 ($\underline{C}OOCH_3$), 162.95, 154.86, 145.19, 144.68, 137.91, 131.23, 126.94, 123.14, 120.95, 117.25, 114.36, 111.82, 89.56 (-O-CH-O-), 56.11 (OCH_3), 52.02 ($COO\underline{C}H_3$), 20.90 ($\underline{C}H_3COO$)

IR (KBr): ν (cm^{-1}) = 3450, 3365 (NH_2), 1760 (CH_3COO), 1715 ($COOCH_3$), 1630, 1615, 1525, 1440, 1375, 1330, 1300.

MS: *m/z* (%) = 403 [M^+] (3), 301 (8), 270 (4), 238 (2), 181 (2), 44 (100).

4-Formyl-2'-methoxy-5'-methoxycarbonyldiphenylether (10)

A solution of (9) (16.6 g, 41.0 mmol) in acetic acid (60 mL) and concentrated hydrochloric acid (30 mL) was cooled to 0 °C. At this temperature, an aqueous solution of Na NO_2 (3.4 g, 50 mmol in 20 mL of H_2O) was added dropwise and the mixture was stirred for 20 min. After addition of H_3PO_2 (80 mL of a 50% aqueous solution), the mixture stirred for 12 h at 0 °C. It was extracted with ether (2 x 100 mL) and the combined organic layer washed with H_2O and dried over Mg SO_4. The solvent was evaporated under vacuum and the residue was purified by column chromatography (silica, CH_2 Cl_2) to give (10) as white needles; yield: 8.9 g (76%); mp 89-91.

^{1}H-NMR: δ = 9.91 (s, 1H, CHO), 7.95 (dd, J_1 = 8.5 Hz, J_2 = 1.9 Hz, 1H, ArH), 7.83 (d, J = 8.7 Hz, 2H, ArH), 7.78 (d, J = 2.0 Hz, 1H, ArH), 7.07 (d, J = 8.6 Hz, 1H, ArH), 6.99 (d, J = 8.6 Hz, 2H, ArH), 3.88 (s, 3H, $COOCH_3$), 3.85 (s, 3H, OCH_3)

^{13}C-NMR: δ = 190.71 (CHO), 166.02 ($\underline{C}OOCH_3$), 163.06, 155.61, 142.86, 131.90, 131.27, 128.53, 123.78, 123.44, 117.19, 116.36, 115.55, 112.24, 56.10 (OCH_3), 52.11 ($COOCH_3$).

IR (KBr): ν (cm^{-1}) = 2950, 1720 ($COOCH_3$), 1700 (CHO),1615, 1605, 1586, 1511, 1460, 1440, 1320.

MS: *m/z* (%) = 286 [M^+] (100), 285 (20), 256 (12), 255 (80), 225 (5), 184 (9), 183 (12).

4-[2-(3-Methoxyphenyl) ethenyl] -2'-methoxy-5'-methoxycarbonyldiphenylether (11)

The diphenylether (10) (1.2 g, 4.2 mmol) and (3-Methoxybenzyl)triphenyl-phosphonium bromide (2 g, 4.3 mmol) were reacted under the conditions given in the general procedure for Wittig reaction. The crude was purified by column chromatography (silica/CH_2 Cl_2) to give (11) (mixture of Z/E isomers) as a colorless oil; yield: 1.2 g (75%).

^{1}H-NMR: δ = 7.92 - 7.47 (m, 4H, ArH), 7.28 - 6.56 (m, 9H, ArH, -CH=CH-), 3.91 - 3.68 (m, 9H, $COOCH_3$, 2x OCH_3).

IR (film): ν (cm^{-1}) = 3065, 2945, 2830, 1720, 1610, 1580, 1510, 1460, 1440.

MS: *m/z* (%) = 390 [M^+] (11), 319 (22), 318 (100), 287 (20), 168 (13).

4-[2-(3-Methoxyphenyl)ethyl]-2'-methoxy-5'-methoxycarbonyldiphenylether (12)

The stilbene (11) (1 g, 2.5 mmol) was hydrogenated in a similar way as described in the general procedure. After purification by column chromatography (silica/CH_2Cl_2), compound (12) was obtained as white needles; yield: 0.89 g (90%); mp 99-100 °C.

^{1}H-NMR: δ = 7.82 (dd, J_1 = 8.5 Hz, J_2 = 2.0 Hz, 1H, ArH), 7.60 (d, J = 2.1 Hz, 1H, ArH), 7.18 (t, J = 7.7 Hz, 1H, ArH), 7.10 (d, J = 8.5 Hz, 2H, ArH), 7.00 (d, J = 8.6 Hz, 1H, ArH), 6.87 (d, J = 8.5 Hz, 2H, ArH), 6.76 - 6.71 (m, 3H, ArH), 3.88 (s, 3H, $COOCH_3$), 3.83 (s, 3H, OCH_3), 3.76 (s, 3H, OCH_3), 2.88 (s, 4H, Ar-CH_2-CH_2-Ar).

^{13}C - NMR: δ = 166.33 ($\underline{C}OOCH_3$), 159.66, 155.20, 145.42, 143.31, 136.34, 129.63, 129.27, 126.62, 123.14, 121.47, 120.91, 117.58, 114.26, 111.86, 111.35, 56.10 (OCH_3), 55.12, 51.91 ($COOCH_3$), 38.00, 37.00 (Ar-CH_2-CH_2-Ar).

IR (film): ν (cm^{-1}) = 2950, 2925, 2835, 1705, 1610, 1585, 1500, 1440, 1335.

MS: *m/z* (%) = 365 [M^+ + H] (11), 364 [M^+] (43), 292 (25), 258 (100), 243 (90), 121 (35).

4-[2-(3-Methoxyphenyl) ethyl]- 5'- hydroxymethyl 2'-methoxydiphenylether (13)

Alcohol (13) was prepared in a similar way as described in the literature[8] by reduction of a THF solution of (12) (1 g, 2.5 mmol) with $LiAlH_4$ (0.15 g, 4.0 mmol). The crude was purified by column chromatography (silica/ether) to give (13) as a colorless oil; yield: 0.8 g (89%).

^{1}H-NMR: δ = 7.20 (t, J = 7.7 Hz, 1H, ArH), 7.09 (d, J = 11 Hz, 2H, ArH), 7.06 (dd, J_1 = 8.5 Hz, J_2 = 2.0 Hz, 1H, ArH), 6.95 (d, J = 8.3 Hz, 1H, ArH), 6.92 (d, J = 2.1 Hz, 1H, ArH), 6.86 (d, J = 11 Hz, 2H, ArH), 6.76 (d, J = 7.7 Hz, 1H, ArH), 6.73 (dd, J_1 = 8.0 Hz, J_2 = 2.0 Hz, 1H, ArH), 6.70 - 6.69 (m, 1H, ArH), 4.54 (s, 2H, Ar-CH_2-OH), 3.83 (s, 3H, OCH_3), 3.76 (s, 3H, OCH_3), 2.83 (s, 4H, Ar-CH_2-CH_2-Ar).

^{13}C-NMR: δ = 159.66, 155.84, 150.76, 145.86, 143.36, 136.12, 134.11, 129.50, 129.27, 122.95, 120.92, 119.32, 117.62, 114.34, 112.96, 111.30, 64.73 (CH_2OH), 56.20 (OCH_3), 55.14 (OCH_3), 38.02, 36.98 (Ar-CH_2-CH_2-Ar).

IR (film): ν (cm^{-1}) = 3385 (OH), 2980, 2835, 2815, 1600, 1580, 1500, 1450, 1435, 1420.

MS: *m/z* (%) = 393 [M^+ + H] (2), 392 [M^+] (7), 286 (13), 271 (100), 121 (13).

4-[2-(3-Methoxyphenyl)ethyl]- 5'-formyl -2'-methoxydiphenylether (14)

Aldehyde (14) was prepared in a similar way as described in the literature[9] by oxidation of a CH_2Cl_2 solution of (13) (1.0 g, 2.7 mmol) with PCC on alumina (54 g). The crude was purified by column chromatography (silica / CH_2Cl_2) affording (14) as a colorless oil; yield: 0.8 g (82%).

^{1}H-NMR: δ = 9.83 (s, 1H, CHO), 7.65 (dd, J_1 = 8.4 Hz, J_2 = 2.0 Hz, 1H, ArH), 7.43 (d, J = 2.0 Hz, 1H, ArH), 7.23 (t, J = 7.7 Hz, 1H, ArH), 7.16 (d, J = 8.5 Hz, 2H, ArH), 7.12 (d, J = 8.4 Hz, 1H, ArH), 6.94 (d, J = 8.5 Hz, 2H, ArH), 6.80 (d, J = 8.0 Hz, 1H, ArH), 6.78 - 6.76 (m, 2H, ArH),

3.98 (s, 3H, OCH_3), 3.81 (s, 3H, OCH_3), 2.93 (s, 4H, Ar-CH_2-CH_2-Ar).

^{13}C - NMR: δ = 190.28 (CHO), 159.72, 156.20, 154.88, 147.01, 143.28, 137.10, 130.33, 129.82, 129.32, 127.62, 120.95, 119.06 116.32, 114.33, 112.10, 111.36, 56,29 (OCH_3), 55.17 (OCH_3), 37.97, 37.03 (Ar-CH_2-CH_2-Ar).

IR (film): ν (cm^{-1}) = 3000, 2930, 2830, 1695, 1600, 1585, 1510, 1460, 1440, 1280, 1230.

MS: *m/z* (%) = 363 [M^+ + H] (13), 362 [M^+] (33), 290 (8), 256 (37), 242 (20), 241 (100), 122 (27).

4-[2-(3-Methoxyphenyl)ethyl] -5'-[2-(2,5-dimethoxyphenyl)ethenyl]-2'-methoxydiphenylether (15)

Aldehyde (14) (1.0 g, 2.7 mmol) and (2,5-Dimethoxybenzyl)triphenylphosphonium chloride (1.25 g, 2.8 mmol) were reacted under the conditions of the general procedure for Wittig reaction. The crude was purified by column chromatography (silica / CH_2Cl_2) to give (15) (mixture of Z/E isomers) as a colorless oil; yield: 1.1 g (80%).

1H-NMR: δ = 7.27 - 6.71 (m, 16H, ArH, Ar-CH=CH-Ar), 3.83 (s, 3H, OCH_3), 3.79 (s, 3H, OCH_3), 3.78 (s, 3H, OCH_3), 3.76 (s, 3H, OCH_3), 2.88 (s, 4H, Ar-CH_2-CH_2-Ar).

IR (film): ν (cm^{-1}) = 2990, 2925, 2825, 1605, 1585, 1510, 1460, 1435, 1275, 1225, 1165, 1125, 1045, 1025, 970, 800.

MS: *m/z* (%) = 497 [M^+ + H] (5), 496 [M^+] (12), 391 (12), 390 (20), 286 (100), 285 (31), 271 (30), 270 (58).

4-[2-(3-Methoxyphenyl)ethyl]- 5'-[2-(2,5-dimethoxyphenyl)ethyl]-2'-methoxydiphenyether (16)

Stilbene (15) (1.0 g, 2.0 mmol) was hydrogenated in a similar way as described in the general procedure. After purification by column chromatography (silica / CH_2Cl_2) compound (16) was obtained as a colorless oil; yield: 0.90 g (90%).

^{1}H-NMR: δ = 7.19 (t, *J* = 7.5 Hz, 1H, ArH), 7.08 (d, *J* = 8.5 Hz, 2H, ArH), 6.93 (dd, J_1 = 8.2 Hz, J_2 = 1.9 Hz, 1H, ArH), 6.89 (d, *J* = 8.2 Hz, 2H, ArH), 6.83 (d, *J* = 8.5 Hz, 2H, ArH), 6.79 (dd, J_1 = 6.4 Hz, J_2 = 1.8 Hz, 1H, ArH), 6.75 (dd, J_1 = 6.6 Hz, J_2 = 3.0 Hz, 1H, ArH), 6.73 - 6.72 (m, 2H, ArH), 6.68 (dd, J_1 = 8.6 Hz, J_2 = 3.0 Hz, 1H, ArH), 6.62 (d, *J* = 3.0 Hz, 1H, ArH), 3.80 (s, 3H, OCH_3), 3.74 (s, 3H, OCH_3), 3.71 (s, 3H, OCH_3), 2.87 (s, 4H, Ar-CH_2-CH_2-Ar), 2.83 - 2.75 (m, 4H, Ar-CH_2-CH_2-Ar).

^{13}C-NMR: δ = 159.71, 156.30, 153.51, 151.66, 149.57, 145.09, 143.45, 135.64, 135.51, 131.31, 129.39, 129.26, 124.35, 121,16, 120.93, 117.10, 116.38, 114.32, 113.04, 111.32, 56.27 (OCH_3), 55.97 (OCH_3), 55.72 (OCH_3), 55.15 (OCH_3), 38.08, 37.00, 35.27, 32.55 (2x Ar-CH_2-CH_2-Ar).

IR (film): ν (cm^{-1}) = 2985, 2925, 2840, 1605, 1585, 1505, 1460, 1440, 1420, 1270, 1225, 1165, 1125, 1045, 1030, 800.

MS: *m/z* (%) = 499 [M^+ + H] (13), 498 [M^+] (29), 393 (10), 392 (28), 303 (31), 302 (86), 288 (11), 287 (15), 152 (85), 151 (100), 136 (21).

14'- Hydroxyperrottetin E (2)

Tetramethoxyether (16) (260 mg, 0.5 mmol) was deprotected as described in the general procedure. Purification by column chromatography (silica / ether) afforded (2) as a colorless oil; yield: 180 mg (80%)

^{1}H-NMR: δ = 7.10 (t, *J* = 7.8 Hz, 1H, ArH), 7.0 4 (d, *J* = 8.5 Hz, 2H, ArH), 6.89 (d, *J* = 8.1 Hz, 1H, ArH), 6.83 (dd, J_1 = 8.2 Hz, J_2 = 2.0, 1H, ArH), 6.80 (d, *J* = 8.5 Hz, 2H, ArH), 6.70 (d, *J* = 7.5 Hz, 1H, ArH), 6.64 (dd, J_1 = 8.2 Hz, J_2 = 2.2 Hz, 1H, ArH), 6.62 (d, *J* = 2.0 Hz, 1H, ArH), 6.57 (d, *J* = 8.5 Hz, 1H, ArH), 6.55 - 6.54 (m, 1H, ArH), 6.49 (dd, J_1 = 8.5 Hz., J_2 = 2.8 Hz, 1H, ArH), 6.46 (d, *J* = 2.8 Hz, 1H, ArH), 2.84 (s, br, 4H, Ar-CH_2-CH_2-Ar), 2.74 (s, 4H, Ar-CH_2-CH_2-Ar).

^{13}C-NMR: δ = 158.24, 157.14, 151.08, 148.76, 147.81, 144.25, 144.00, 136.64, 135.19, 130.28, 130.04, 129.64, 125.63, 121.59, 120.45, 117.73, 117.62, 116.42, 116.26, 114.01, 113.67, 38.62, 37.55, 35.85, 33.53.

IR (film): ν (cm^{-1}) = 3400 (OH), 2940, 2860, 1590, 1510, 1400, 1280, 1220, 1170, 1110, 1020.

MS: *m/z* (%) = 442 [M^+ + H] (100), 335 (46), 334 (51), 319 (63), 318 (70), 227 (9), 226 (14), 123 (30), 107 (30).

4-[2-(2,5-Dimethoxyphenyl)ethenyl]-2'-methoxy-5'-methoxycarbonyl-diphenylether (17)

The aldehyde (10) (1.2 g, 4.2 mmol) and (2,5-Dimethoxybenzyl)triphenyl-phosphonium chloride (2.0 g, 4.4 mmol) were reacted under the condition of the general procedure for Wittig reaction. The crude was purified by column chromatography (silica / CH_2Cl_2) to give (17) (mixture of Z/E isomers) as a colorless oil; yield: 1.5 g (85%).

^{1}H-NMR: δ = 7.87 - 6.91 (m, 7H, ArH), 6.62 - 6.56 (m, 5H, ArH, -CH=CH-), 3.67 - 3.57 (m, 12H, $COOCH_3$, 3x OCH_3).

IR (film): ν (cm^{-1}) = 3065, 2945, 2830, 1720, 1610, 1580, 1510, 1460, 1440.

MS: *m/z* (%) = 421 [M^+ + H] (26), 420 [M^+] (100), 377 (9), 270 (11), 150 (13).

4-[2-(2,5-Dimethoxyphenyl)ethyl]-2'-methoxy-5'-methoxycarbonyldiphenylether (18)

Stilbene (17) (1 g, 2.3 mmol) was hydrogenated in a similar way as described in the general procedure. Purification by column chromatography (silica/CH_2Cl_2) afforded (18) as colorless crystal; yield: 0.90 g (90%); mp 50-52 °C.

^{1}H-NMR: δ = 7.82 (dd, J_1 = 8.5 Hz, J_2 = 2.0 Hz, 1H, ArH), 7.60 (d, *J* = 2.0 Hz, 1H, ArH), 7.13 (d, *J* = 8.5 Hz,

2H, ArH), 6.98 (d, J = 8.5 Hz, 1H, ArH), 6.87 (d, J = 8.6 Hz, 2H, ArH), 6.76 (dd, J_1 = 8.2 Hz, J_2 = 3.0 Hz, 1H, ArH), 6.68 (dd, J_1 = 8.0 Hz, J_2 = 3.0 Hz, 2H, ArH), 3.88 (s, 3H, OCH_3), 3.82 (s, 3H, OCH_3), 3.75 (s, 3H, OCH_3), 3.72 (s, 3H, $COOCH_3$), 2.89 - 2.82 (m, 4H, Ar-CH_2-CH_2-Ar).

^{13}C-NMR: δ = 166.33 ($\underline{C}OOCH_3$), 155.32, 155.13, 153.44, 151.79, 145.45, 137.04, 131.37, 129.64, 126.55, 123.05, 121.29, 117.51, 116.27, 111.76, 111.29, 111.19, 56.07 (OCH_3), 55.91 (OCH_3), 55.63 (OCH_3), 51.91 (COO$\underline{C}H_3$), 35.44, 32.55 (Ar-CH_2-CH_2-Ar)

IR (film): ν (cm $^{-1}$) = 2985, 2935, 2820, 1715 (C=O), 1605, 1585, 1500, 1455, 1435, 1320.

MS: *m/z* (%) = 423 [M^+ + H] (23), 422 [M^+](84), 272 (17), 271 (100), 151 (19)

4-[2-(2,5-Dimethoxyphenyl)ethyl]-5'- hydroxymethyl-2'-methoxydiphenylether (19)

Alcohol (19) was prepared in a similar way as described in the literature[8] by reduction of a THF solution of (18) (1.0 g, 2.4 mmol) with $LiAlH_4$ (0.15 g, 0.4 mmol). The crude was purified by column chromatography (silica/ether) to give (19) as white crystals; yield: 0.84 g (89%); mp 51-53 °C.

^{1}H-NMR: δ = 7.10 (d, J = 8.5 Hz, 2H, ArH), 7.06 (dd, J_1 = 8.3 Hz, J_2 = 1.8 Hz, 1H, ArH), 6.94 (d, J = 8.3 Hz, 1H, ArH), 6.90 (d, J = 1.8 Hz, 1H, ArH), 6.87 (d, J = 8.5 Hz, 2H, ArH), 6.76 (d, J = 8.3 Hz, 1H, ArH), 6.68 (dd, J_1 = 8.6 Hz, J_2 = 3.0 Hz, 1H, ArH), 6.66 (d, J = 3.0 Hz, 1H, ArH), 4.52 (s, 2H, Ar-CH_2-OH), 3.83 (s, 3H, OCH_3), 3.76 (s, 3H, OCH_3), 3.72 (s, 3H, OCH_3), 2.88 - 2.80 (m, 4H, Ar-CH_2-CH_2-Ar).

^{13}C-NMR: δ = 155.58, 153.41, 151.85, 150.64, 145.96, 136.78, 134.06, 131.43, 129.57, 122.82, 119.07, 117.69, 116.41, 112.77, 111.31, 111.18, 64.71 (CH_2OH), 56.16 (OCH_3), 55.98 (OCH_3), 55,72 (OCH_3), 35.41, 32.61 (Ar-CH_2-CH_2-Ar).

IR (film): ν (cm $^{-1}$) = 3515 (OH), 2985, 2920, 2815, 1610, 1585, 1500, 1455, 1425, 1270.

MS: *m/z* (%) = 395 [M^+ + H] (20), 394 [M^+](54), 244 (28), 243 (100), 196 (17), 151 (22)

4-[2-(2,5-Dimethoxyphenyl)ethyl]-2'-methoxy-5'-formyldiphenylether (20)

Aldehyde (20) was prepared in a similar way as described in the literature[9] by oxidation of a CH_2Cl_2 solution of (19) (1.0 g, 2.5 mmol) with PCC on alumina (54 g). The crude was purified by column chromatography (silica / CH_2Cl_2) affording (20) as white crystals; yield: 0.86 g (86%), mp 86-88 °C.

^{1}H-NMR: δ = 9.79 (s, 1H, CHO), 7.61 (dd, J_1 = 8.3 Hz, J_2 = 1.9 Hz, 1H, ArH), 7.38 (d, J = 1.9 Hz, 1H, ArH), 7.15 (d, J = 8.4 Hz, 2H, ArH), 7.08 (d, J = 8.3 Hz, 1H, ArH), 6.90 (d, J = 8.4 Hz, 2H, ArH), 6.77 (d, J = 8.4 Hz, 1H, ArH), 6.71 - 6.67 (m, 2H, ArH), 3.95 (s, 3H, OCH_3), 3.77 (s, 3H, OCH_3), 3.75 (s, 3H, OCH_3), 2.89 - 2.85 (m, 4H, Ar-CH_2-CH_2-Ar).

^{13}C-NMR: δ = 190.35 (CHO), 156.09, 154.60, 153.45, 151.82, 147.08, 137.73, 131.34, 130.22, 129.83, 127.51, 118.81, 118.31, 116.35, 111.99, 111.30, 111.19, 56.26 (OCH_3), 55.95 (OCH_3), 55,68 (OCH_3), 35.47, 32.52 (Ar-CH_2-CH_2-Ar).

IR (film): ν (cm $^{-1}$) = 2920, 2815, 2700, 1690 (C=O), 1600, 1580, 1500, 1455, 1435, 1395, 1275. 1235, 1120

MS: *m/z* (%) = 393[M^+ + H] (29), 392 [M^+](100), 242 (14), 241 (87), 151 (43), 121 (14)

4-[2-(2,5-Dimethoxyphenyl)ethyl]-2'-methoxy-5'-[2-(3-methoxyphenyl)ethenyl]- diphenylether (21)

Aldehyde (20) (1.2 g, 3.0 mmol) and (3-Methoxybenzyl)triphenylphosphonium bromide (1.6 g, 3.5 mmol) were reacted under the conditions of the general procedure for Wittig reaction. The crude was purified by column chromatography (silica / CH_2Cl_2) to give (21) as a colorless oil; yield: 1.3 g (85%).

^{1}H-NMR: δ = 7.45 (dd, J_1 = 8.5 Hz, J_2 = 2.1 Hz, 1H, ArH), 7.31 (d, J = 2.1 Hz, 1H, ArH), 7.12 (d, J = 8.4 Hz, 2H, ArH), 7.01- 6.66 (m, 9H, ArH, Ar-CH=CH-Ar), 6.47 (d, J = 8.1 Hz, 1H, ArH), 6.42 (d, J = 13 Hz, 1H, ArH), 6.12 (d, J = 8.1 Hz, 1H, ArH), 3.85 - 3.72 (m, 12H, OCH_3), 2.88 -2.83 (m, 4H, Ar-CH_2-CH_2-Ar).

IR (film): ν (cm $^{-1}$) = 2995, 2935, 2830, 1610, 1510, 1465, 1445, 1430, 1280, 1230.

MS: *m/z* (%) = 497[M^+ + H] (6), 496 [M^+](20), 390 (20), 345 (100), 377 (4), 257 (30).

4-[2-(2,5-Dimethoxyphenyl)ethyl]-2'-methoxy-5'-[2-(3-methoxyphenyl)ethyl]-diphenylether (22)

Stilbene (21) (2 g, 4.0 mmol) was hydrogenated as described in the general procedure. Purification by column chromatography (silica/CH_2Cl_2) afforded (22) as a colorless oil; yield: 1.8 g (90%).

^{1}H-NMR: δ = 7.15 (t, J = 8.0 Hz, 1H, ArH), 7.10 (d, J = 8.5 Hz, 2H, ArH), 6.88 (d, J = 1.2 Hz, 2H, ArH), 6.82 (d, J = 8.5 Hz, 2H, ArH), 6.76 - 6.75 (m, 2H, ArH), 6.71 (dd, J_1 = 7.7 Hz, J_2 = 1.9 Hz, 1H, ArH), 6.69 - 6.66 (m, 4H, ArH), 3.80 (s, 3H, OCH_3), 3.75 (s, 3H, OCH_3), 3.74 (s, 3H, OCH_3), 2.87 - 2.83 (m, 4H, Ar-CH_2-CH_2-Ar), 2.81 (s, br, 4H, Ar-CH_2-CH_2-Ar).

^{13}C-NMR: δ = 159.68, 156.02, 153.53, 151.88, 149.60, 145.33, 143.18, 136.35, 134.81, 131.55 129.44, 129.26, 124.16, 123,43, 120.92, 117.16, 116.38, 114.26, 113.03, 111.36, 111. 23, 56.21 (OCH_3), 55.98 (OCH_3), 55.69 (OCH_3), 55.11 (OCH_3), 37.93, 36.82, 35.46, 32.59 (2x Ar-CH_2-CH_2-Ar).

IR (film): ν (cm $^{-1}$) = 2995, 2935, 2825, 1610, 1590, 1505, 1465, 1445, 1425, 1275, 1225, 1130, 1125, 1045, 1030, 800.

MS: *m/z* (%) = 499 [M^+ + H] (44), 498 [M^+](100), 377 (5), 348 (17), 347 (67).

14- Hydroxyperrottetin E (3)

Tetramethoxyether (22) (1.5 g, 3 mmol) was deprotected as described in the general procedure. Purication by column chromatography (silica / ether) afforded (3) as a colorless oil; yield: 1.0 g (80%)

^{1}H-NMR: δ = 7.11 (d, *J* = 8.5 Hz, 2H, ArH), 7.0 6(t, *J* = 7.8 Hz, 1H, ArH), 6.90 (d, *J* = 8.1 Hz, 1H, ArH), 6.82 (d, *J* = 2.0, 1H, ArH), 6.81 (d, *J* = 8.5 Hz, 2H, ArH), 6.64 - 6.54 (m, 4H, ArH), 6.54 - 6.53 (not resolved, 2H, ArH), 6.52 (d, *J* = 4.3 Hz., 1H, ArH), 2.86 - 2.82 (m, 4H, Ar-CH_2-CH_2-Ar), 2.76 (s, 4H, Ar-CH_2-CH_2-Ar).

^{13}C-NMR: δ = 156.57, 155.38, 149.72, 147.74, 145.86, 143.55, 143.34, 137.09, 134.22, 129.82, 129.36, 124.50, 120.28, 119.67, 117.57, 117.02, 116.35, 116.01, 115.58, 113.47, 112.92, 38.00, 36.90, 35.24, 32.47.

IR (film): ν (cm $^{-1}$) = 3360 (OH), 2920, 2850, 1690, 1600, 1510, 1455, 1350, 1270, 1220, 1110, 960, 815, 780.

MS: *m/z* (%) = 443 [M^+ + H] (14), 442 [M^+](45), 350 (13), 335 (17), 320 (23), 319 (100), 229 (35), 227 (47), 211 (19), 123 (83).

4-[2-(2,5-Dimethoxyphenyl)ethyl]-5'-[2-(2,5-dimethoxyphenyl)ethenyl]-2'-methoxydiphenylether (23)

Aldehyde (20) (1.2 g, 3.0 mmol) and (2,5-Dimethoxybenzyl)triphenylphosphonium chloride (1.5 g, 3.3 mmol) were reacted under the conditions of the general procedure for Wittig reaction. The crude was purified by column chromatography (silica / CH_2Cl_2) to give (23) (mixture of Z/E isomers) as a colorless oil; yield: 1.4 g (80%).

^{1}H-NMR: δ = 7.28 - 7.16 (m, 3H, ArH), 7.12 (d, *J* = 8.3 Hz, 2H, ArH), 7.09 - 7.08 (not resolved, 1H, ArH), 6.98 (d, *J* = 6.6 Hz, 1H, ArH), 6.94 (not resolved, 1H, ArH) 6.89 (d, *J* = 8.3 Hz, 2H, ArH), 6.80 - 6.67 (m, 5H, ArH, Ar-CH=CH-Ar), 3.84 (s, 3H, OCH_3), 3.79 (s, 3H, OCH_3), 3.78 (s, 3H, OCH_3), 3.76 (s, 3H, OCH_3), 3.71 (s, 3H, OCH_3), 2.86 -2.85 (m, 4H, Ar-CH_2-CH_2-Ar).

IR (film): ν (cm $^{-1}$) = 2990, 2935, 2825, 1725, 1610, 1510, 1465, 1430, 1275, 1230.

MS: *m/z* (%) = 527[M^+ + H] (9), 526 [M^+](26), 391 (27), 390 (100), 375 (100), 165 (18), 150 (22), 122 (21), 121 (20).

4, 5'-Bis-[2-(2,5-dimethoxyphenyl)ethyl]-2'-methoxydiphenylether (24)

Stilbene (23) (1.0 g, 1.9 mmol) was hydrogenated as described in the general procedure. After purification by column chromatography (silica / CH_2Cl_2), compound (24) was obtained as a colorless oil; yield: 0.9 g (90%).

^{1}H-NMR: δ = 7.10 (d, *J* = 8.5 Hz, 2H, ArH), 6.93 (d, *J* = 1.8 Hz, 1H, ArH), 6,91 - 6.89 (not resolved, 1H, ArH), 6.83 (d, *J* = 8.5 Hz, 2H, ArH), 6.79 (d, *J* = 1.8 Hz, 1H, ArH), 6.76 - 6.68 (m, 4H, ArH), 6.66 (d, *J* = 3.0 Hz, 1H, ArH), 6.62 (d, *J* = 3.0 Hz, 1H, ArH), 3.79 (s, 3H, OCH_3), 3.76 (s, 3H, OCH_3), 3.73 (s, 3H, OCH_3), 3.72 (s, 3H, OCH_3), 2.87 - 2.82 (m, 4H, Ar-CH_2-CH_2-Ar), 2.81 - 2.75 (m, 4H, Ar-CH_2-CH_2-Ar).

^{13}C-NMR: δ = 156.13, 153.48, 151.83, 149.52, 145.14, 136.26, 135.45, 131.55, 131.26, 129.44 124.27, 121.08, 117.07, 116,36, 112.93, 111.33, 111.23, 56.22 (OCH_3), 55.97 (OCH_3), 55.93 (OCH_3), 55.69 (2x OCH_3), 35.47, 35.27, 32.61 (2x Ar-CH_2-CH_2-Ar).

IR (film): ν (cm $^{-1}$) = 2995, 2940, 2855, 1615, 1595, 1510, 1465, 1430, 1280, 1225, 1130, 1055, 1030, 805.

MS: *m/z* (%) = 529 [M^+ + H] (35), 528 [M^+](100), 378 (12), 377 (46), 270 (10), 238 (11), 212 (11), 151 (21), 121 (11).

14,14'-Dihydroxyperrottetin E (4)

Pentamethoxyether (24) (0.5 g, 0.9 mmol) was deprotected as described in the general procedure. Purification by column chromatography (silica / ether) afforded (4) as a colorless oil; yield: 0.37 g (91%)

^{1}H-NMR: δ = 7.05 (d, *J* = 8.4 Hz, 2H, ArH), 6.87 (d, *J* = 8.1 Hz, 1H, ArH), 6.82 (dd, J_1 = 8.1 Hz, J_2 = 1.6 Hz, 1H, ArH), 6.78 (d, *J* = 8.4 Hz, 2H, ArH), 6.62 - 6.60 (not resolved, 2H, ArH), 6.57 (d, *J* = 8.4 Hz, 1H, ArH), 6.51 (d, *J* = 3.0 Hz., 1H, ArH), 6.49 (not resolved, 2H, ArH), 6.46 (dd, J_1 = 8.8 Hz, J_2 = 3.0 Hz, 1H, ArH), 2.82 (s, br, 4H, Ar-CH_2-CH_2-Ar), 2.73 (s, 4H, Ar-CH_2-CH_2-Ar).

^{13}C-NMR: δ = 156.26, 149.59, 147.68, 147.58, 145.61, 143.64, 136.98, 134.67, 129.82, 129.26, 129.21, 124.42, 119.53, 117.65, 117.08, 116.26, 116.11, 113.47, 35.21, 35.10, 32.62, 32.35.

IR (film): ν (cm $^{-1}$) = 3345 (OH), 2970, 2830, 2865, 1685, 1605, 1510, 1455, 1355, 1285, 1210, 1110, 960, 815, 735.

MS: *m/z* (%) = 459 [M^+ + H] (5), 458 [M^+](10), 336 (38), 335 (100), 246 (58), 228 (13), 227 (21), 213 (25), 123 (4).

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