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Acid-catalyzed Solvolysis of Polyenol Ethers. III. Effect of the Alkoxy Moiety[1,2].

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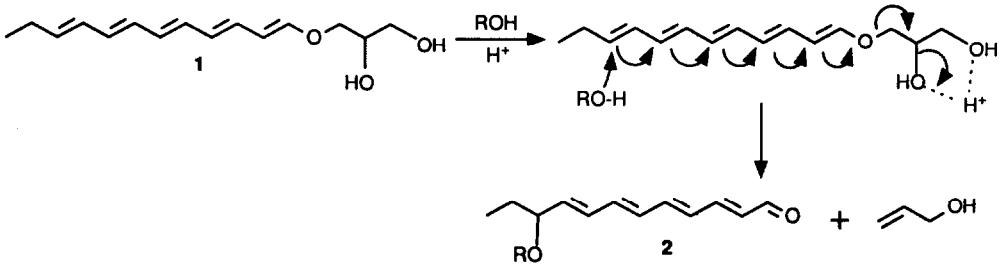
ABSTRACT. The dependence of the solvolysis of polyenol ethers on the nature of the alkoxy moiety has been studied. A new reaction path, leading to the formation of ω-hydroxy (methoxy) substituted aldehydes and -esters, was established. The proposed reaction pathway (scheme **6**) is initiated by an electron transfer from the polyenol ether to molecular oxygen, followed by combination of the two radicals to a peroxide zwitterion. Upon protonation, solvent adds to the ω-carbon atom of the polyene to give an intermediate that can either loose water to form an ester, or loose the alkoxy moiety to give an aldehyde. This mechanism is believed to be involved in the strong mutagenic activity displayed by many polyenol ethers, including the natural mutagen fecapentaene-12.

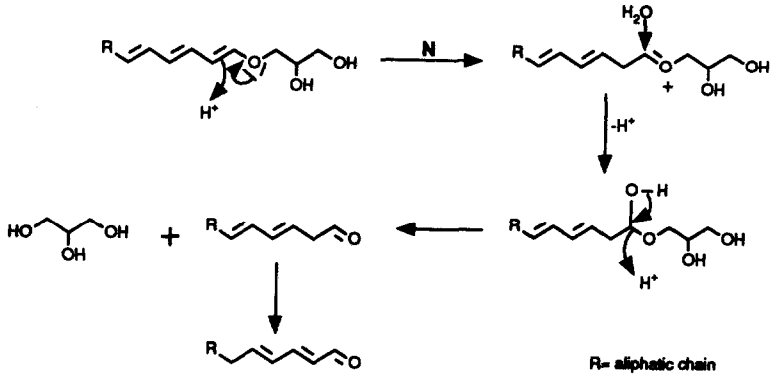
INTRODUCTION. Studies on the acid-catalyzed solvolysis of polyenol ethers of glycerol, in particular of the naturally occurring potent mutagen fecapentaene-12 (**1**, Scheme 1), have revealed the existence of an anomalous solvolytic pathway[1]. This pathway (**A**, Scheme 1) leads to the formation of unsaturated aldehydes **2**, substituted by the nucleophilic solvent at the original ω-carbon atom of the polyene. Support for this mechanism was obtained by the isolation of allyl alcohol, formed by loss of water from the glyceryl-



Scheme 1. *Anomalous solvolysis pathway A.*

moiety, from the solvolysis mixture. It was subsequently shown[2] that only glyceryl enol ethers with one and two double bonds follow the normal enol ether solvolysis pathway (**N**, Scheme 2). This well-established pathway[3] starts with protonation at the β-carbon atom, followed by addition of water (or alcohol) at C-α and formation of an aldehyde (or acetal). Glyceryl enol ethers with three conjugated double bonds gave mixtures of compounds stemming from both solvolyic pathways[2]. Extension of the conjugation beyond this point served to completely suppress the normal pathway **N** and increase the rate of the anomalous reaction **A**.

Obviously, the dihydroxylated glyceryl moiety plays a major role in determining the course of the solvolysis reaction. This led us to a systematic study of the role of the alkoxy substituent in the solvolysis of polyenol ethers, which is reported here.



Scheme 2. *Normal hydrolysis pathway N.*

Enol ethers of glycol were considered to be the most simple compounds that could potentially react via the anomalous pathway, which is triggered by protonation of a β'-hydroxy group and loss of water from the alkoxy moiety (Scheme 1). As will be shown in the sequel, glycyl enol ethers reacted to give rather complex mixtures of products. This led us to the study of enol ethers that were supposedly better tailored towards solvolysis by reaction path **A**, namely:

- enol ethers of 1,2-dihydroxypropane (methylglycol), in which the positive charge to be created in the alkoxy chain would be situated at a secondary, rather than a primary carbon atom;
- enol ethers of 1,2-dihydroxy-1-phenylethane (phenylglycol), in which this positive charge is at a benzylic position. In this case, also the thermodynamic situation should improve, as the developing double bond becomes conjugated with the aromatic ring. As will be shown, the results obtained with these enol ethers pointed to the existence of still another solvolytic pathway;
- to verify this mechanism, a polyenol ether of 4-methoxyphenylglycol was studied;
- finally, enol ethers of propanol, not containing a β-hydroxy substituent in the alkoxy-chain and thus not capable of reacting via a pathway similar to **A**, were investigated.

METHODS AND MATERIALS

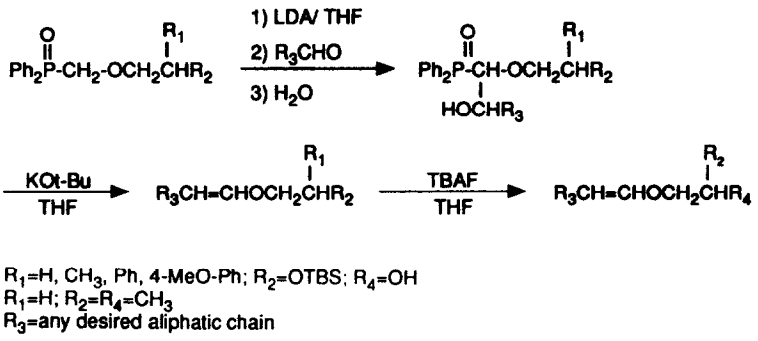
Synthesis of starting materials

Enol ethers

The polyenol ethers here were synthesized by, or in analogy to, the method developed earlier in our laboratory[4], using the Horner-Wittig reaction to create the enol ether double bond (Scheme 3). The requisite aldehydes were either obtained commercially or synthesized by the Wollenberg method[5], using the modifications described in our earlier proceedings[1].

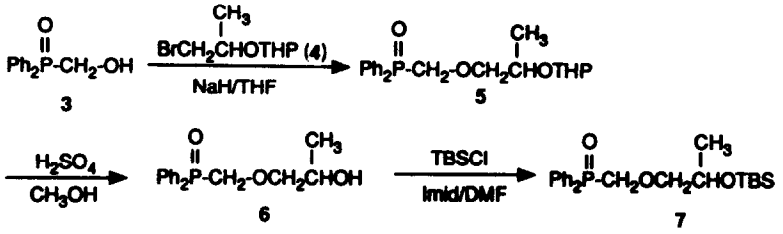
Phosphine oxides

Synthesis of the phosphine oxides, required for the synthesis of polyenol ethers of glycol and propanol have been reported earlier[4]. Phosphine oxide **7**, required for the synthesis of polyenol ethers of methyl glycol,



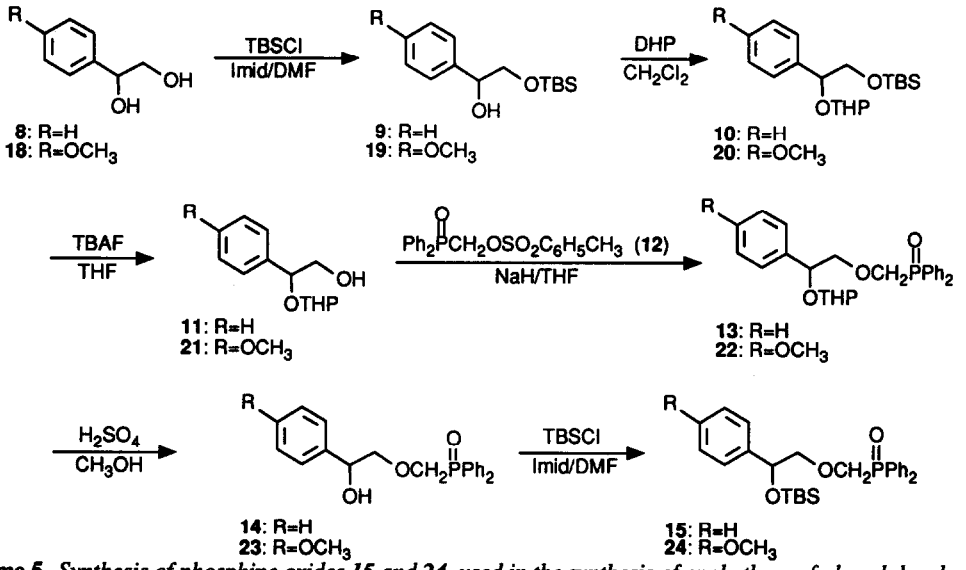
Scheme 3. *General reaction route for the synthesis of polyenol ethers, using the Horner-Wittig reaction.*

was synthesized as indicated in scheme 4.



Scheme 4. *Synthesis of phosphine oxide 7, used in the synthesis of enol ethers of methylglycol*[6].

Phosphine oxide **15**, required for the synthesis of polyenol ethers of phenylglycol, was synthesized starting from 1-phenyl-1,2-ethanediol (**8**), as indicated in Scheme 5[7] . Interestingly, treatment of **8** with 1.0 equiv of TBSCl afforded in 96% yield the primary mono-TBS-protected 1-phenyl-1,2-ethanediol **9**. Only 0.5% of the secondary mono-TBS-protected and 1.5% bis-TBS-protected 1-phenyl-1,2-ethanediol were formed. Protection of 1-phenyl-1,2-ethanediol has been described earlier[8], but a comparably high selectivity had not been achieved. Phosphine oxide **24**, required for the synthesis of polyenol ethers of 4-methoxyphenylglycol, was synthesized in analogy to **15**. For the synthesis of the starting compound 1'-(4-methoxyphenyl)-1',2'-ethanediol (**18**), a method developed by Holshouser was used[9]. 4-Methoxyacetophenone was treated with bromine, affording α-bromo-4-methoxyacetophenone (**16**). **16** Was then treated with sodium acetate, using iodide catalysis, to yield α-acetoxy-4-methoxyacetophenone (**17**), which was treated with $LiAlH_4$ to give the desired diol **18**. Protection of **18** with TBSCl this time resulted in the formation of 84% primary mono-TBS-protected, 12% secondary mono-TBS-protected and 2% bis-TBS-protected 1'-(4-methoxyphenyl)-1',2'-ethanediol. The decrease in selectivity for silylation of the primary alcohol compared to **8** is mainly due to formation of a larger amount of the secondary silyl ether (12 versus 0.5%). This probably reflects the stabilizing effect of the 4-methoxyphenyl group on the (partial) positive charge on oxygen in the transition state, leading to silylation of the secondary hydroxyl group.



Scheme 5. *Synthesis of phosphine oxides 15 and 24, used in the synthesis of enol ethers of phenylglycol and 4-methoxyphenylglycol.*

RESULTS

Acid-catalyzed solvolysis of polyenol ethers of glycol

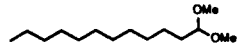
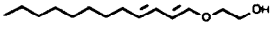
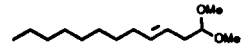
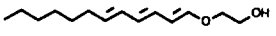
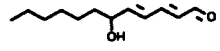
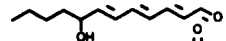
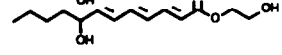
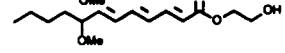
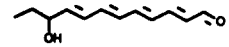
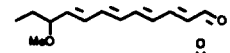
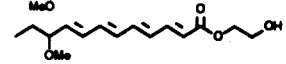
Enol ethers with one (**26**) and two (**27**) conjugated double bonds reacted similar to their glyceryl counterparts[2]. In THF/water mixtures (reaction conditions I) they formed the unsubstituted aldehydes dodecanal (**28**)[10] and 2-dodecenal (**29**)[10], respectively (Table 1). Using methanol/water (reaction conditions II) next to these aldehydes, acetals were formed: **26** formed 1,1-dimethoxydodecane (**30**)[10] and **27** gave 1,1-dimethoxydodec-3-ene (**31**)[10] (Table 1). The unsaturated acetal **31** is apparently formed directly from the enol ether, as intermediacy of the unsaturated aldehyde **29** would have led to a different position of the double bond.

Trienol ether **32** showed a change in mechanism similar to what was observed for its glyceryl counterpart[2]. Under reaction conditions I, next to the unsubstituted aldehyde 2,4-dodecadienal (**33**)[10], an ω-hydroxy-substituted aldehyde, 6-hydroxy-2,4-dodecadienal (**34**)[10] was formed (Table 1). Using reaction conditions II, the same two products were obtained. Remarkably, selective addition of water had occured, from a medium containing 50% of methanol.

With tetraenol ether **35** a new phenomenon was observed. Next to ω-substituted aldehydes, ω-substituted esters were formed. Using reaction conditions I, 8-hydroxy-2,4,6-dodecatrienal (**36**)[10] and 2'-hydroxyethyl 8-hydroxy-2,4,6-dodecatrienoate (**37**) were formed. Under reaction conditions II, 8-methoxy-2,4,6-dodecatrienal (**38**)[10] and 2'-hydroxyethyl 8-methoxy-2,4,6-dodecatrienoate (**39**) were the only reaction products (Table 1). It is worthy of note that the preferential addition of water from a water/methanol mixture, observed with trienol ether **32**, does not occur in longer conjugated systems like **35**.

Applying reaction conditions I, pentaenol ether **40** gave the same reaction product as its glyceryl counterpart fecapentaene-12[1], i.e.: 10-hydroxy-2,4,6,8-dodecatetraenal (**41**)[10]. Using reaction conditions II, next to 10-methoxy-2,4,6,8-dodecatetraenal (**42**)[10], the ester 2'-hydroxyethyl 10-methoxy-2,4,6,8-dodeca-

TABLE 1. Acid catalyzed solvolysis of polyenol ethers of glycol.

Enol ether	Reaction conditions[a]	Reaction time (h)	Reaction product	Yield[b]
26: 	I	2.5	**28:** 	86%
	II	0.5	**28**	18%
			30: 	57%
27: 	I	72	**29:** 	32%
	II	5	**29**	35%
			31: 	7%
32: 	I	16	**33:** 	17%
			34: 	15%
	II	5	**33**	10%
			34	21%
35: 	I	8	**36:** 	19%
			37: 	15%
	II	7.25	**38:** 	21%
			39: 	7%
40: 	I	4.5	**41:** 	21%
	II	4.5	**42:** 	18%
			43: 	3%

a) I: THF/water (50/50; v/v), II: methanol/water (50/50; v/v)

b) Isolated yield after flash column chromatography.

tetraenoate (**43**) was isolated (Table 1).

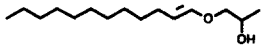
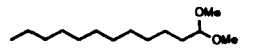
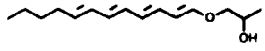
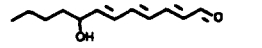
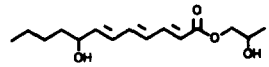
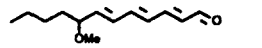
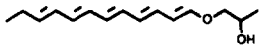
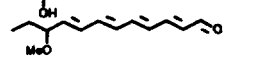
Acid-catalyzed solvolysis of polyenol ethers of methylglycol

On the basis of the experience gained with the polyenol ethers of glycol, a limited number of polyenol ethers was selected. Only enol ethers with one, four, and five double bond(s) were studied (Table 2). Enol ether **44** was expected to follow a normal hydrolysis pattern. The tetraenol ether **45** was chosen because it was anticipated to form ω-substituted esters. Finally, the pentaenol ether **47** could serve for direct comparison with the well-studied natural mutagen fecapentaene-12. As expected, **44** reacted in the acid-catalyzed solvolysis using reaction conditions I (THF/water) to produce dodecanal (**28**)[10]. Using a methanol/water mixture (reaction conditions II), besides **28**, 1,1-dimethoxydodecane (**30**)[10] was formed.

Tetraenol ether **45** produced the ω-substituted aldehyde **36**$^{(10)}$ under reaction conditions I, together with the ester 2'-hydroxypropyl 8-hydroxy-2,4,6-dodecatrienoate (**46**). Using reaction conditions II, besides the hydroxy-, also the methoxy-substituted aldehyde **38**$^{(10)}$ was formed.

Using reaction conditions I, pentaenol ether **47** reacted to give 10-hydroxytetraenal **41**$^{(10)}$ as the sole product. When reaction conditions II were applied only 10-methoxytetraenal **42**$^{(10)}$ was produced.

TABLE 2. Acid-catalyzed solvolysis of polyenol ethers of methylglycol.

Enol ether	Reaction conditions[a]	Reaction time (h)	Reaction product	Yield[b]
44: 	I	3	**28**: 	75%
	II	1	**28**	35%
			30: 	57%
45: 	I	5	**36**: 	30%
			46: 	4%
	II	5	**36**	19%
			38: 	18%
47: 	I	4.5	**41**: 	17%
	II	4.5	**42**: 	17%

a) I: THF/water (50/50; v/v); II: methanol/water (50/50; v/v).

b) Isolated yield after flash column chromatography.

Acid-catalyzed solvolysis of polyenol ethers of phenylglycol

Again, enol ethers containing one, four, and five double bonds were studied (Table 3).

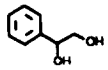
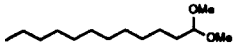
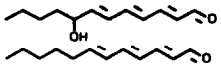
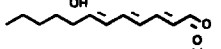
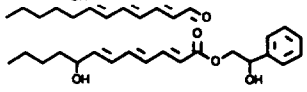
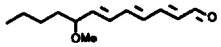
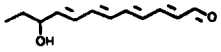
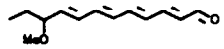
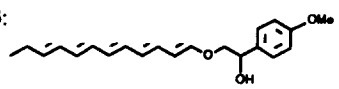
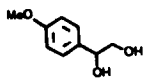
Using reaction conditions I, enol ether **48** hydrolyzed to the expected aldehyde **28**$^{(10)}$ and diol **8**. When reaction conditions II were applied, besides these two compounds acetal **30**$^{(10)}$ was formed. Solvolysis of enol ether **49** gave an unexpected result. When reaction conditions I were applied, besides hydroxytrienal **36**$^{(10)}$ and small amounts of 2,4,6-dodecatrienal (**50**) and 2'-phenyl-2'-hydroxyethyl 8-hydroxy-2,4,6-dodecatrienoate (**51**), a large amount of 1-phenyl-1,2-ethanediol (**8**) was isolated. This diol cannot be formed by the earlier proposed solvolysis mechanism A$^{(1,2)}$, in which water is lost from the alkoxy moiety. Formation by a normal hydrolysis reaction (N) is unlikely, because only traces of the corresponding unsaturated aldehyde were found. An alternative pathway will be proposed in the discussion. Solvolysis under reaction conditions II revealed a similar picture: besides **36**$^{(10)}$ and methoxytrienal **38**$^{(10)}$, again a substantial amount of diol **8** was formed.

Using reaction conditions I, the fecapentaene-12 analogue **52** reacted to give 10-hydroxytetraenal **41**$^{(10)}$ as well as diol **8**. When reaction conditions II were applied, 10-methoxytetraenal **42**$^{(10)}$ and diol **8** were formed.

Acid-catalyzed solvolysis of a polyenol ether of 4-methoxyphenylglycol

The 4-methoxyphenyl group was introduced to study the role of a strongly stabilizing substituent at C-2 of the alcohol moiety. Because of the rather lengthy synthetic pathway needed to prepare these enol ethers,

TABLE 3. Acid-catalyzed solvolysis of polyenol ethers of phenylglycol and 4-methoxyphenylglycol.

Enol ether	Reaction conditions[a]	Reaction time(h)	Reaction product	Yield[b]
48: 	I	4	**8**: 	36%
			28: 	85%
	II	3	**8**	35%
			28	27%
			30: 	66%
49: 	I	3	**8**	44%
			36: 	23%
			50: 	3%
			51: 	5%
	II	4	**8**	31%
			36	11%
			38: 	9%
52: 	I	4	**8**	57%
			41: 	19%
	II	4	**8**	42%
			42: 	12%
53: 	I	3.5	**18**: 	41%
			41	16%
	II	5	**18**	37%
			42	28%

a) I: THF/water (50/50; v/v); II: methanol/water (50/50; v/v).

b) Isolated yield after flash column chromatography.

we restricted our efforts to the fecapentaene-12 analogue **53** containing five conjugated double bonds. Using reaction conditions I, enol ether **53** reacted to give not only 10-hydroxytetraenal **41**$^{(10)}$, but also (4-methoxyphenyl)diol **18**, thus confirming the results obtained with **52**. When reaction conditions II were applied, 10-methoxytetraenal **42**$^{(10)}$ and again diol **18** were formed (Table 3).

Acid-catalyzed solvolysis of polyenol ethers of propanol

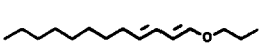
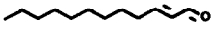
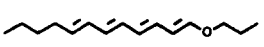
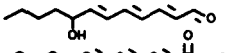
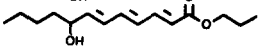
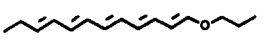
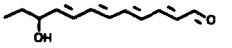
Because the members of this series do not contain a ß-hydroxy substituent in the alkoxy moiety, they cannot engage in solvolysis of type **A**, which is initiated by loss of water from a protonated hydroxyl group in this moiety. As these enol ethers do not dissolve in methanol, the acid-catalyzed solvolysis reactions were only performed in THF/water mixtures (reaction conditions I). The enol ethers chosen for this series contained two, four and five double bonds. (The enol ether with two double bonds was selected as a model compound to

observe the normal hydrolysis (pathway **N**) because of its ease of detection, compared to the enol ether with only one double bond.)

Dienol ether **55** reacted as expected, to give 2-dodecenal (**29**)[10] as the sole product. Tetraenol ether **56** reacted to give 8-hydroxytrienal **36**[10] and the ester propyl 8-hydroxy-2,4,6-dodecatrienoate (**57**). From enol ether **58**, containing five double bonds, only hydroxytetraenal **41**[10] was isolated (Table 4).

Thus, despite the fact that these polyenol ethers cannot react according to route **A**, ω-substituted aldehydes are still formed. This indicates the existence of another pathway by which ω-substitution can occur.

TABLE 4. Acid-catalyzed solvolysis of polyenol ethers of propanol.

Enol ether	Reaction conditions[a]	Reaction time (h)	Reaction product	Yield[b]
55: 	I	47	**29**: 	20%
56: 	I	2.5	**36**: 	8%
			57: 	10%
58: 	I	3	**41**: 	11%

a) I: THF/water (50/50; v/v)

b) Isolated yield after flash column chromatography.

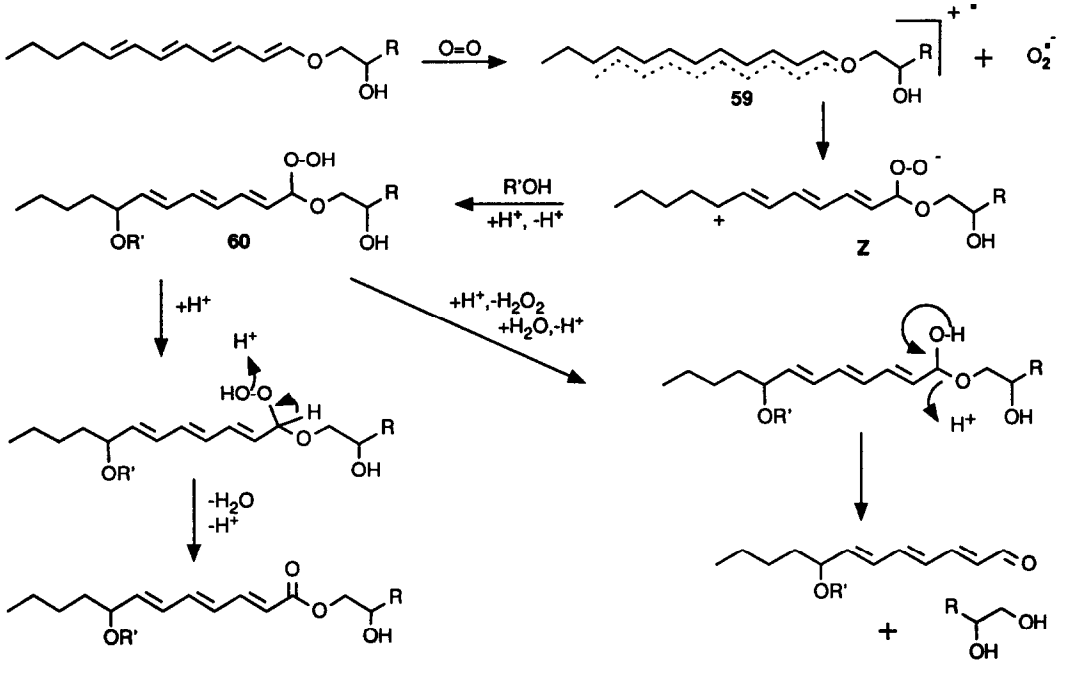
DISCUSSION. The general pattern in the acid-catalyzed solvolysis is quite consistent throughout the series of enol ethers tested and resembles that, encountered with the polyenol ethers of glycerol[1,2]. A striking new phenomenon observed in this study was the formation of ω-substituted polyunsaturated **esters**. They are formed from enol ethers containing at least three double bonds in conjugation with the enol ether double bond.

The formation of these esters must involve the addition of solvent to the ω-carbon atom of the polyene chain but cannot be explained by the ionic pathway A (Scheme 1), proposed for the formation of ω-substituted unsaturated aldehydes from polyenol ethers of glycerol[1]. Formation of the ester group by oxidation of a hemiacetal, such as the one occurring as an intermediate in the normal hydrolysis pathway **N**, (Scheme 2) is unlikely in view of the reaction conditions used. Also, any pathway starting with protonation at either the ß- or ω-carbon atom of the polyene chain could never lead to alkoxy (hydroxy) substitution at the ω-polyene carbon atom. Significantly, the difference in molecular mass between the enol ethers studied and the resulting ω-hydroxy esters is exactly 32. In our opinion, the formation of ω-substituted esters during the acid-catalyzed solvolysis of polyenol ethers can best be explained by a mechanism in which a one-electron transfer to oxygen occurs in the first step. This mechanism, illustrated in Scheme 6, has recently been supported by MO-calculations[11]. It is assumed that the highly electron-rich polyenol ether donates an electron to oxygen, traces of which are always present in the solvent mixture. This results in formation of a radical carbocation **59** from the enol ether and a radical anion from oxygen. Combination of these radicals produces a zwitterion **Z**, which upon protonation and addition of the nucleophilic solvent at the original ω-carbon atom of the polyene chain forms the neutral peroxide **60**. Formation of ω-substituted trienoic esters can now be easily envisaged by acid

catalyzed loss of water as indicated.

The electron transfer mechanism is also consistent with the formation of large amounts of 1-phenyl-1,2-ethanediol (**8**) in the acid-catalyzed solvolysis of polyenol ethers **49** and **52**, where reaction via the ionic mechanism **A** would have led to formation of styrene. When protonation of intermediate **60** occurs at the carbon-bound oxygen atom of the peroxide instead of at the oxygen-oxygen bond, hydrogen peroxide will be easily lost and addition of water will provide hemiacetal **61**, which will rapidly lose the alcohol moiety to form the corresponding aldehyde. Alternatively, the neutral peroxide intermediate may decompose by a radical pathway, involving homolytic cleavage of the oxygen-oxygen bond.

It is important to note here that by the mechanism depicted in Scheme 6, the same ω-substituted polyunsaturated aldehydes are formed that are produced by following the ionic hydrolysis pathway **A**. Formation of ω-substituted polyunsaturated esters, which was not observed during the solvolysis of the glyceryl pentaenol ether fecapentaene-12, can only be explained by the electron-transfer pathway.



Scheme 6. *Suggested one-electron transfer mechanism, explaining the formation of ω -substituted polyunsaturated esters, aldehydes and diols 8 and 18.*

More information on the relative importance of the ionic and radical pathways, which in principle can occur side-by-side, was obtained by studying the effect of added radical scavenger on the outcome of the solvolysis. When solvolysis of the glyceryl enol ether fecapentaene-12 (**1**) was carried out in the presence of the radical scavenger butylated hydroxytoluene (BHT), the same products were still formed, but the product yield dropped by about 20%. When the same reaction conditions were applied to the pentaenol ether **40** of glycol, the solvolysis reaction was completely inhibited. This shows that at least for the enol ethers derived from

glycol, and probably for all the enol ethers tested, the acid-catalyzed solvolysis proceeds largely or exclusively by the electron transfer pathway.

Attempts to increase the yield of electron-transfer initiated products by the addition of extra oxygen to the solvolysis mixture were not successful. As it turned out, this induced an increase in the rate of polymerization of both starting material and reaction products. Experiments in which extra efforts were made to decrease the amount of oxygen available, showed a decrease in the amounts of ω-substituted products formed and a corresponding increase in polymer formation. Apparently, there is a delicate balance between the yield of solvolysis products that can be obtained from these polyunsaturated enol ethers and the amount of oxygen available.

Although this one-electron transfer mechanism only appears to play a relatively minor role in the acid-catalyzed solvolysis of the natural mutagen fecapentaene-12 itself, the fact that it occurs at all is of major importance for understanding the biological activities displayed by this compound. It illustrates that this pentaenol ether will react with traces of oxygen, even in an oxygen-poor environment, to engage in a process by which peroxides are formed. Peroxides are known to be initiators of radical processes in cells that cause different kinds of oxidative damage, in particular lipid peroxidation and genetic damage by oxidation of DNA-bases. Such damage, resulting from exposure of cells to fecapentaene-12, has indeed been shown to occur recently[12].

As shown in this paper, autoxidation via a radical mechanism appears to play a major role in the degradation of polyenol ethers derived from alcohols other than glycerol. This provides an explanation for the recent observation that pentaenol ethers of glycol, methylglycol and propanol are in fact potent mutagens[12].

In summary, the present study on the course of the acid-catalyzed solvolysis of fecapentaene analogues with a systematically varied alkoxy moiety has revealed the existence of an additional pathway by which polyenol ethers can solvolyse. Insight in the mechanism by which oxygen interacts with these compounds has contributed to our understanding of the chemistry which underlies the mutagenic activity of polyenol ethers in general and that of fecapentaene-12 in particular.

Experimental

GENERAL

^{1}H and ^{13}C nmr spectra were recorded on a Jeol JNM FX-200 or on a Bruker 300-MHz spectrometer. The chemical shifts are given in ppm (δ) relative to tetramethylsilane as an internal reference. Coupling constants (J) are given in Hz. The compounds were measured in deuteriochloroform as solvent. Mass spectral data were obtained with an AEI MS 902 and a Kratos MS 9/50 apparatus. Uv absorptions were recorded on a Varian DMS 200 spectrometer, using 96% ethanol as the solvent. Flash column chromatography was performed with silica gel (230-400 mesh, Merck). Solvents and reagents were used as high grade commercial products. All syntheses were carried out under protection from light, in an inert atmosphere. *E/Z*-ratio's of enol ethers were measured using ^{13}C nmr and GC data; column: CPSIL-5CB, oven temp. 100-250°C, rise 7°C/min. The aldehydes used for the synthesis of the enol ethers were produced using the method developed by Wollenberg, using the modifications described earlier[1]. 2*E*,4*E*,6*E*-undecatrienal and 2*E*,4*E*,6*E*,8*E*-undecatetraenal were described in detail in our previous report[2].

Synthesis of Starting Materials

2-(2-BROMOPROPOXY)TETRAHYDRO-(2H)-PYRAN (4)

To a solution of 54.0 g (388.5 mmol) 1-bromo-2-propanol in 100 ml of dichloromethane, containing 0.7 g (3.9

mmol) of *p*-toluenesulfonic acid monohydrate (*p*-TsOH.H_2O), 65.8 g (783.3 mmol) of 2,3-dihydropyran dissolved in 100 ml of dichloromethane was added dropwise. After stirring for 0.5 h in an inert atmosphere at room temperature, the reaction was complete. The reaction mixture was neutralized by addition of saturated, aqueous, sodium hydrogen carbonate (150 ml). The resulting aqueous solution was extracted with dichloromethane (3 x 100 ml). The combined organic layers were washed with saturated brine (2 x 100 ml), dried with anhydrous potassium carbonate and evaporated *in vacuo*. Distillation (90-105°C/ 10-15 Torr) afforded pure **4**. Yield: 79.8 g, 357.8 mmol, (92%); colourless oil.

^{1}H nmr: δ 1.32 (6H, d(2x), J=6.0(2x), CH_3, *isomer 1+2*), 1.4-1.8 (12H, m, $(CH_2)_3$, *isomer 1+2*), 3.3-4.0 (10H, m, [$BrCH_2$, $CH_3\underline{C}HO$, CH_2O], *isomer 1+2*), 4.5 (1H, t, OCHO, *isomer 1/2*), 4.9 (1H, t, OCHO, *isomer 1/2*) ppm.

^{13}C nmr: δ 18.28, 20.24 (CH_3, *isomer 1+2*), 19.30, 19.48, 25.26(2x), 30.54, 30.81 (($CH_2)_3$, *isomer 1+2*), 36.38, 37.38 (CH_2Br, *isomer 1+2*), 62.37, 62.49 (CH_2O, *isomer 1+2*), 71.74, 72.12 ($CH_3\underline{C}HO$, *isomer 1+2*), 97.00, 98.20 (OCHO, *isomer 1+2*) ppm.

[[2-[TETRAHYDROPYRANYL]OXY]PROPOXY]METHYLDIPHENYLPHOSPHINE OXIDE (5)

To a suspension of sodium hydride (3.8 g, 87.6 mmol, 55-60% dispersion in mineral oil, washed with petroleum ether 40-60°C) and **4** (15.9 g, 76.6 mmol) in dry THF (200 ml), hydroxymethyldiphenylphosphine oxide (**3**)[13] (13.6 g, 58.6 mmol) was added over a period of 1 h at room temperature in an inert atmosphere. The suspension was refluxed for 16 h. Subsequently, the reaction mixture was poured into water (100 ml) and extracted with chloroform (3 x 100 ml). The combined organic layers were washed with saturated brine (2 x 100 ml). *In vacuo* evaporation of the solvent, followed by purification by flash column chromatography (5% methanol and 10% triethylamine in ether), afforded 17.5 g (46.9 mmol, 80%) pure phospine oxide **5** as a colourless oil.

ms: m/z 375 (13), 374 (M^+, 29), 315 (49), 273 (28), 246 (15), 216 (100), 215 (72), 202 (72), 201 (33), 91 (21), 85 (43), 77 (18). Exact mass: 374.1660 ($C_{21}H_{27}O_4P$ requires 374.1646).

^{1}H nmr: δ 1.04 (3H, d, J=6.2, CH_3, *isomer 1/2*), 1.13 (3H, d, J=6.2, CH_3, *isomer 1/2*), 1.4-1.8 (12H, m, $(CH_2)_3$, *isomer 1+2*), 3.4-4.0 (10H, m, [$CH_2\underline{C}H_2O$, OCH_2, $C\underline{H}CH_3$], *isomer 1+2*), 4.29 (2H, d, PCH_2, $^1J_{HP}$=6.9, *isomer 1/2*), 4.35 (2H, d, PCH_2, $^1J_{HP}$=6.9, *isomer 1/2*), 4.6 (1H, t, OCHO, *isomer 1/2*), 4.7 (1H, t, OCHO, *isomer 1/2*), 7.4-7.6 (12H, m, Ph_2PO, *isomer 1+2*), 7.8-7.9 (8H, m, Ph_2PO, *isomer 1+2*) ppm.

^{13}C nmr: δ 16.00, 18.22 (CH_3, *isomer 1+2*), 19.30, 19.63, 25.29(2x) 30.81(2x) (($CH_2)_3$, *isomer 1+2*), 61.93, 62.52 ($CH_2\underline{C}H_2O$, *isomer 1+2*), 69.67(2x) (d(2x), $^1J_{CP}$=88(2x), PCH_2, *isomer 1+2*), 69.90, 71.83 (CHO, *isomer 1+2*), 77.86(2x) (d(2x), $^3J_{CP}$=10(2x), OCH_2, *isomer 1+2*), 95.78, 98.84 (OCHO, *isomer 1+2*), 128.10(8x) (d(8x), $^3J_{CP}$=12(8x), $Ph_2PO(C_{meta})$, *isomer 1+2*), 130.98(2x) (d(2x), $^1J_{CP}$=99(2x), $Ph_2PO(C_{ipso})$, *isomer 1/2*), 131.12(8x) (d(8x), $^2J_{CP}$=7(8x), $Ph_2PO(C_{ortho})$, *isomer 1+2*), 131.14(2x) (d(2x), $^1J_{CP}$=100(2x), $Ph_2PO(C_{ipso})$, *isomer 1/2*), 131.69 (4x) ($Ph_2PO(C_{para})$, *isomer 1+2*) ppm.

^{31}P nmr: δ 27.80, 27.74 (*isomer 1+2*) ppm.

[2-HYDROXYPROPOXY]METHYLDIPHENYLPHOSPHINE OXIDE (6)

17.5 g (46.9 mmol) of phospine oxide **5** was dissolved in methanol (50 ml) and 1.5 ml of a 20% aqueous sulfuric acid solution was added. After stirring for 1 h at room temperature, the reaction mixture was neutralized by addition of saturated, aqueous, potassium hydrogen carbonate (40 ml). The methanol was evaporated *in vacuo* and the resulting aqueous solution was extracted with chloroform (3 x 50 ml). The combined organic layers were washed with saturated brine (2 x 25 ml) and dried with anhydrous magnesium sulfate. Evaporation of the solvent *in vacuo* afforded the crude phosphine oxide **6**, which was purified by flash column chromatography (5% methanol and 10% triethylamine in ether). Yield: 11.6 g, 40.0 mmol, (85%); colourless oil.

ms: m/z 290 (M^+, 1), 275 (53), 216 (88), 215 (100), 201 (51), 183 (16), 125 (15), 91 (33), 77 (42), 45 (18), 31 (24). Exact mass: 290.1076 ($C_{16}H_{19}O_3P$ requires 290.1071).

^{1}H nmr: δ 1.05 (3H, d, J=6.2, CH_3), 3.49 (1H, tq, J=6.2, J=7.0, C<u>H</u>OH), 3.9-4.0 (2H, m, $OC\underline{H}_2CH$), 4.33 (2H, d, $^1J_{HP}$=4.8, PCH_2), 7.4-7.6 (6H, m, Ph_2PO), 7.8-7.9 (4H, m, Ph_2PO) ppm.

^{13}C nmr: δ 18.54 (CH_3), 65.93 (CHOH), 69.47 (d, $^1J_{CP}$=88, PCH_2), 79.66 (d, $^3J_{CP}$=9, OCH_2), 128.51(4x) (d(4x), $^3J_{CP}$=12(4x), $Ph_2PO(C_{meta})$), 130.44(2x) (d(2x), $^1J_{CP}$=94(2x), $Ph_2PO(C_{ipso})$), 131.20(4x) (d(4x),

$^2J_{CP}$=9(4x), $Ph_2PO(C_{ortho})$), 132.13(2x) ($Ph_2PO(C_{para})$ ppm.
^{31}P nmr: δ 28.86 ppm.

[2-[[(1,1DIMETHYLETHYL)DIMETHYLSILYL]OXY]PROPOXY]METHYLDIPHENYLPHOSPHINE OXIDE (7)

In an inert atmosphere, phosphine oxide **6** (10.6 g, 36.4 mmol) was dissolved in dry dimethylformamide (DMF) (40 ml). Imidazole (6.2 g, 91 mmol) and *tert*-butyldimethylsilylchloride (6.6 g, 43.9 mmol) were added at room temperature. After stirring for 45 min at this temperature, the solution was poured into water (25 ml) and extracted with ether (3 x 50 ml). The combined organic layers were washed with water (2 x 25 ml), dried with anhydrous magnesium sulfate and evaporated *in vacuo*. Distillation (205-215°C/ 0.1-0.2 Torr) afforded pure **7**. Yield: 12.8 g, 32.6 mmol, (90%); colourless oil.

ms: m/z 404 (M^+, 1), 347 (100), 216 (42), 201 (22), 185 (11), 135 (25), 91 (22), 73 (62). Exact mass: 404.1940 ($C_{22}H_{33}O_3PSi$ requires 404.1936).

^1H nmr: δ 0.01 (6H, s(2x), $Si(CH_3)_2$), 0.88 (9H, s(3x), $C(CH_3)_3$), 1.07 (3H, d, J=6.2, CH_3), 3.45 (1H, tq, J=6.2(2x), CHOSi), 3.9-4.0 (2H, m, OCH_2), 4.35 (2H, d, $^1J_{HP}$=6.2, PCH_2), 7.4-7.6 (6H, m, Ph_2PO), 7.8-7.9 (4H, m, Ph_2PO) ppm.

^{13}C nmr: δ -4.82(2x) ($Si(CH_3)_2$), 17.96 ($\underline{C}(CH_3)_3$), 20.53 (CH_3), 25.70(3x) ($C(\underline{C}H_3)_3$), 67.34 (CHOSi), 69.90 (d, $^1J_{CP}$=88, PCH_2), 79.64 (d, $^3J_{CP}$=10, OCH_2), 128.36(4x) (d(4x), $^3J_{CP}$=12(4x), $Ph_2PO(C_{meta})$), 131.21(2x) (d(2x), $^1J_{CP}$=98(2x), $Ph_2PO(C_{ipso})$), 131.39(4x) (d(4x), $^2J_{CP}$=10(4x), $Ph_2PO(C_{ortho})$), 131.95(2x) ($Ph_2PO(C_{para})$ ppm.
^{31}P nmr: δ 28.05 ppm.

1'-PHENYL-[2'-[(1,1-DIMETHYLETHYL)DIMETHYLSILYL]OXY]ETHANOL (9)

In an inert atmosphere, 10.0 g (72.5 mmol) of 1-phenyl-1,2-ethanediol was dissolved in dry dimethylformamide (DMF) (70 ml). Imidazole (9.9 g, 145.0 mmol) and *tert*-butyldimethylsilylchloride (10.9 g, 72.5 mmol) were added at room temperature. After stirring overnight at this temperature, the solution was poured into water (100 ml) and extracted with ether (3 x 100 ml). The combined organic layers were washed with saturated brine (2 x 50 ml), dried with anhydrous magnesium sulfate and evaporated *in vacuo*. Flash column chromatography (10% triethylamine in petroleum ether 40-60°C), afforded pure **9**. Yield: 17.8 g, 70.6 mmol, (96%); colourless oil.

ms: m/z 254 (14), 253 ($(M+H)^+$, 70), 235 (70).

IR: 3620-3260, 3090, 3070, 3040, 2960, 2940, 1495, 1460, 1110, 1065 cm^{-1}.

^1H nmr: δ 0.02 (6H, s(2x), $Si(CH_3)_2$), 0.88 (9H, s(3x), $C(CH_3)_3$), 3.52 (1H, dd, J_{trans}=8.4, J_{gem}=-10.5, HC$\underline{H}$OSi), 3.71 (1H, dd, J_{cis}=3.7, J_{gem}=-10.5, $\underline{H}$CHOSi), 4.69 (1H, dd, J_{cis}=3.7, J_{trans}=8.4, C$\underline{H}$OH), 7.2-7.3 (5H, m, Ph) ppm.

^{13}C nmr: δ -5.52(2x) ($Si(CH_3)_2$), 18.19 ($\underline{C}(CH_3)_3$), 25.78(3x) ($C(\underline{C}H_3)_3$), 68.85 (CH_2OSi), 74.20 (CHOH), 126.09(2x), 128.07(2x) ($Ph(C_{ortho}\ C_{meta})$), 127.52 ($Ph(C_{para})$), 140.36 ($Ph(C_{ipso})$) ppm.

1'-PHENYL-[1'-[TETRAHYDROPYRANYL]OXY]-2'-[[(1,1-DIMETHYLETHYL)DIMETHYLSILYL]-OXY]ETHANE (10)

To a solution of 17.8 g (70.6 mmol) **9** in 100 ml of dichloromethane, containing 143.0 mg (0.7 mmol) *p*-TsOH.H_2O, 11.9 g (141.2 mmol) of 2,3-dihydropyran dissolved in 50 ml of dichloromethane was added dropwise. After stirring overnight in an inert atmosphere at room temperature, the reaction was complete. The reaction mixture was neutralized by addition of saturated, aqueous sodium hydrogen carbonate (100 ml). The resulting aqueous solution was extracted with dichloromethane (3 x 100 ml). The combined organic layers were washed with saturated brine (2 x 100 ml), dried with anhydrous potassium carbonate and evaporated *in vacuo*. Flash column chromatography (10% triethylamine in petroleum ether 40-60°C) afforded pure **10**. Yield: 21.9 g, 65.0 mmol, (92%); colourless oil.

ms: m/z 338 (53), 337 ($(M+H)^+$, 99), 322 (14), 305 (20), 253 (39), 235 (100), 179 (19), 147 (32), 121 (24), 102 (92).

IR: 3070, 3040, 2940, 1495, 1470, 1460, 1125, 1080 cm^{-1}.

^1H nmr: δ 0.03 (6H, s(2x), $Si(CH_3)_2$, *isomer 1/2*), 0.04 (6H, s(2x), $Si(CH_3)_2$, *isomer 1/2*), 0.89 (9H, s(3x),

$C(CH_3)_3$, *isomer 1/2*), 0.90 (9H, s(3x), $C(CH_3)_3$, *isomer 1/2*), 1.4-2.0 (12H, m, $(CH_2)_3$, *isomer 1+2*), 3.3-4.1 (8H, m, [CH_2O, CH_2OSi], *isomer 1+2*), 4.5 (1H, t, OCHO, *isomer 1/2*), 4.7-4.8 (2H, m, CHO, *isomer 1+2*), 5.1 (1H, t, OCHO, *isomer 1/2*), 7.2-7.4 (10H, m, Ph, *isomer 1+2*) ppm.

^{13}C nmr: δ -5.55(4x) ($Si(CH_3)_2$, *isomer 1+2*), 18.14, 18.25, 18.75, 19.01, 30.40, 30.49 ($(CH_2)_3$, *isomer 1+2*), 19.63(2x) ($\underline{C}(CH_3)_3$, *isomer 1+2*), 25.43(3x), 25.75(3x) ($C(\underline{C}H_3)_3$, *isomer 1+2*), 61.12, 61.67 (CH_2O, *isomer 1+2*), 67.71, 68.44 (CH_2OSi, *isomer 1+2*), 77.47, 79.07 (CHO, *isomer 1+2*), 94.52, 98.96 (OCHO, *isomer 1+2*), 126.55(2x), 127.11(2x), 127.34(2x), 127.55(2x), 127.93(2x) ($Ph(C_{ortho}, C_{meta}, C_{para})$, *isomer 1+2*) 139.58, 140.51 ($Ph(C_{ipso})$, *isomer 1+2*) ppm.

2-PHENYL-[2-[TETRAHYDROPYRANYL]OXY]ETHANOL (11)

To 24.6 g (73.2 mmol) of **10**, dissolved in 100 ml of THF, 25.4 g (80.4 mmol) of tetrabutylammonium fluoride trihydrate ($Bu_4NF.3H_2O$) dissolved in 50 ml of THF, was added at 0°C. After stirring overnight, the reaction was complete. The reaction mixture was poured into water (150 ml) and the THF layer was separated. The water layer was extracted with ether (3 x 100 ml). The combined organic layers were washed with saturated brine (2 x 50 ml), dried with anhydrous potassium carbonate and evaporated *in vacuo*. Pure **11** was obtained after flash column chromatography (60% ether, 30% petroleum ether 40-60°C and 10% triethylamine). Yield: 13.7 g, 61.5 mmol, (84%); colourless oil.

ms: m/z 205 ($(M\text{-}OH)^+$, 1), 103 (14), 85 (100).

IR: 3600-3200, 3025, 2940, 1490, 1450, 1160, 1120 cm^{-1}.

^1H nmr: δ 1.4-1.9 (12H, m, $(CH_2)_3$, *isomer 1+2*), 3.2-4.0 (8H, m, [CH_2O, CH_2OH], *isomer 1+2*) 4.5 (1H, t, OCHO, *isomer 1/2*), 4.72 (1H, dd, J_{cis}=4.3, J_{trans}=7.7, CHO, *isomer 1/2*), 4.81 (1H, dd, J_{cis}=4.3, J_{trans}=7.7, CHO, *isomer 1/2*), 4.9 (1H, t, OCHO, *isomer 1/2*), 7.2-7.4 (10H, m, Ph, *isomer 1+2*) ppm.

^{13}C nmr: δ 19.16, 20.03, 25.11(2x), 30.37, 30.81 ($(CH_2)_3$, *isomer 1+2*), 62.20, 63.39 (CH_2O, *isomer 1+2*), 66.49, 67.25 (CH_2OH, *isomer 1+2*), 79.60, 80.18 (CHO, *isomer 1+2*), 97.47, 98.84 (OCHO, *isomer 1+2*), 126.49(2x), 126.61(2x), 127.34, 127.72, 128.04(2x), 128.25(2x) ($Ph(C_{ortho}, C_{meta}, C_{para})$, *isomer 1+2*), 138.61, 139.84 ($Ph(C_{ipso})$, *isomer 1+2*) ppm.

[[2-[TETRAHYDROPYRANYL]OXY]-2-PHENYLETHOXY]METHYLDIPHENYLPHOSPHINE OXIDE (13)

A suspension of sodium hydride (3.2 g, 133.0 mmol, 55-60% dispersion in mineral oil, washed with petroleum ether 40-60°C) and 13.7 g (61.7 mmol) of **11**, dissolved in 200 ml of dry THF, were stirred for 40 min at 50°C in an inert atmosphere. After cooling the reaction mixture to -10°C, 19.2 g (51.5 mmol) of phosphine oxide **12**[13], dissolved in 50 ml of dry THF, was added over a period of 15 min. Subsequently the mixture was stirred overnight at 80°C. After completion of the reaction, water (100 ml) was added. The THF layer was separated and the water layer extracted with ether (3 x 100 ml). The combined organic layers were washed with saturated brine (3 x 100 ml), dried with anhydrous magnesium sulfate and evaporated *in vacuo*. Flash column chromatography (5% methanol and 10% triethylamine in ether) afforded pure **13**. Yield: 15.5 g, 35.6 mmol, (69%); white solid.

ms: m/z 409 ($(M\text{-}C_5H_{10}O_2)^+$, 4), 215 (100), 201 (26), 167 (15).

IR: 2940, 1585, 1440, 1230, 1185, 1120 cm^{-1}.

^1H nmr: δ 1.4-1.8 (12H, m, $(CH_2)_3$, *isomer 1+2*), 3.2-3.8 (8H, m, [$CH_2\underline{CH_2}O$, OCH_2], *isomer 1+2*), 4.2-4.4 (4H, m, PCH_2, *isomer 1+2*), 4.5 (1H, t, OCHO, *isomer 1/2*), 4.8 (1H, t, OCHO, *isomer 1/2*), 4.8-4.9 (2H, m, $CH_2\underline{C}HO$, *isomer 1+2*), 7.2-7.3 (10H, m, Ph, *isomer 1+2*), 7.4-7.6 (12H, m, Ph_2PO, *isomer 1+2*), 7.8-7.9 (8H, m, Ph_2PO, *isomer 1+2*) ppm.

^{13}C nmr: δ 18.78, 18.90, 25.05, 25.20, 30.34, 30.46 ($(CH_2)_3$, *isomer 1+2*), 61.52, 61.64 ($CH_2\underline{C}H_2O$, *isomer 1+2*), 69.67(2x) (d(2x), $^1J_{CP}$=88(2x), PCH_2, *isomer 1+2*), 75.45(2x) (CHO, *isomer 1+2*), 76.90(2x) (d(2x), $^3J_{CP}$=10(2x), OCH_2, *isomer 1+2*), 94.90, 98.40 (OCHO, *isomer 1+2*), 126.44(4x), 127.28(2x), 130.79(4x) ($Ph(C_{ortho}, C_{para}, C_{meta})$, *isomer 1+2*), 126.44(4x) (d(4x), $^2J_{PC}$=9(4x), $Ph_2PO(C_{ortho})$, *isomer 1/2*), 127.68(8x) (d(8x), $^3J_{CP}$=10(8x), $Ph_2PO(C_{meta})$, *isomer 1+2*), 130.78(4x) (d(4x), $^2J_{PC}$=9(4x), $Ph_2PO(C_{ortho})$, *isomer 1/2*), 130.79(4x), (d(4x) $^1J_{PC}$=100(4x), $Ph_2PO(C_{ipso})$, *isomer 1+2*), 131.28(2x), 131.87(2x) ($Ph_2PO(C_{para})$, *isomer 1+2*), 136.86, 137.88 ($Ph(C_{ipso})$, *isomer 1+2*) ppm.

^{31}P nmr: δ 27.34, 28.08 (*isomer 1+2*) ppm.

[2-HYDROXY-2-PHENYLETHOXY]METHYLDIPHENYLPHOSPHINE OXIDE (14)

This phosphine oxide was synthesized on a 35.6 mmol scale in analogy to phosphine oxide **6**, using pure phosphine oxide **13** as the starting material. Reaction time: 1 h. Purification: flash column chromatography (5% methanol and 10% triethylamine in ether). Yield: 10.9 g, 31.0 mmol, (87%); colourless oil.

ms: m/z 354 (21), 353 (M^+, 99), 335 (37), 217 (80), 203 (45), 185 (15), 136 (58), 117 (31), 102 (100).

IR: 3500-3140, 3060, 3040, 1590, 1490, 1440, 1180, 1120, 1030 cm^{-1}.

^1H nmr: δ 3.6-3.8 (2H, m, OCH_2), 4.34 (2H, d, $^1J_{HP}$=5.5, PCH_2), 4.86 (1H, dd, J_{cis}=3.8, J_{trans}=7.9, C<u>H</u>OH), 7.2-7.3 (5H, m, Ph), 7.3-7.5 (6H, m, Ph_2PO), 7.6-7.8 (4H, m, Ph_2PO) ppm.

^{13}C nmr: δ 69.28 (d, $^1J_{CP}$=86, PCH_2), 72.04 (CHOH), 79.15 (d, $^3J_{CP}$=10, OCH_2), 126.03(2x), 127.14, 127.84(2x) (Ph(C_{ortho}, C_{para}, C_{meta}), 128.25(4x) (d(4x), $^3J_{CP}$=12(4x), $Ph_2PO(C_{meta})$), 130.38(2x) (d(2x), $^1J_{CP}$=100(2x), $Ph_2PO(C_{ipso})$), 131.03(4x) (d(4x), $^2J_{CP}$=10(4x), $Ph_2PO(C_{ortho})$), 131.87 ($Ph_2PO(C_{para})$), 140.83 ($Ph(C_{ipso})$) ppm.

^{31}P nmr: δ 28.55 ppm.

[2'-[[(1,1-DIMETHYLETHYL)DIMETHYLSILYL]OXY]-(2'-PHENYL)ETHOXY]METHYLDIPHENYLPHOSPHINE OXIDE (15)

This phosphine oxide was synthesized on a 31.0 mmol scale in analogy to phosphine oxide **7**, using pure phosphine oxide **14** as the starting material. Reaction time 1 h. Purification: flash column chromatography (5% methanol and 10% triethylamine in ether). Yield: 13.2 g, 28.4 mmol, (92%); colourless oil.

ms: m/z 468 (24), 467 ($(M+H)^+$, 68), 335 (68), 235 (92), 217 (50), 203 (28), 136 (47), 132 (100).

IR: 2950, 2920, 1580, 1460, 1435, 1190, 1120, 1095 cm^{-1}.

^1H nmr: δ 0.01, 0.20 (6H, s(2x), $Si(CH_3)_2$), 0.92 (9H, s(3x), $C(CH_3)_3$), 3.5-3.9 (2H, m, OCH_2), 4.2-4.4 (2H, m, PCH_2), 4.85 (1H, m, CHOSi), 7.3-7.4 (5H, m, Ph), 7.4-7.6 (6H, m, Ph_2PO), 7.7-7.9 (4H, m, Ph_2PO) ppm.

^{13}C nmr: δ -5.05, -4.93 ($Si(CH_3)_2$), 18.05 ($\underline{C}(CH_3)_3$), 25.67(3x) ($C(\underline{C}H_3)_3$), 69.93 (d, $^1J_{CP}$=88, PCH_2), 73.82 (CHOSi), 79.99 (d, $^3J_{CP}$=10, OCH_2), 126.23(2x), 127.34, 127.95(2x) (Ph(C_{ortho}, C_{para}, C_{meta})), 128.30(4x) (d(4x), $^3J_{CP}$=12(4x), $Ph_2PO(C_{meta})$), 131.12(2x) (d(2x), $^1J_{CP}$=99(2x), $Ph_2PO(C_{ipso})$), 131.36(4x) (d(4x), $^2J_{CP}$=10(4x), $Ph_2PO(C_{ortho})$), 131.87(2x) ($Ph_2PO(C_{para})$), 141.71 ($Ph(C_{ipso})$) ppm.

^{31}P nmr δ 27.43 ppm.

α-BROMO-4-METHOXYACETOPHENONE (16)

To a solution of 24.9 g (166.0 mmol) 4-methoxyacetophenone, dissolved in 100 ml of chloroform, 26.7 g (333.8 mmol) of bromine was added dropwise at 0°C in 1 h. Subsequently, the reaction mixture was stirred for 4 h at room temperature. The reaction mixture was neutralized by addition of saturated aqueous sodium carbonate (150 ml). The aqueous solution was extracted with chloroform (3 x 100 ml). The combined organic layers were washed with saturated brine (2 x 100 ml), dried with anhydrous sodium carbonate and evaporated *in vacuo*. The crude product was crystallized from petroleum ether 40-60°C/ toluene (1/1). Yield of **16**: 17.7 g, 77.3 mmol, (47%); white crystals, mp: 69-70°C (lit. 14, 70-71°C).

ms: m/z 231 (5), 230 ($M^+(Br^{81})$, 42), 228 ($M^+(Br^{79})$, 42), 135 (100), 121 (30), 107 (25), 92 (39), 84 (40), 77 (55), 49 (54), 18 (33).

IR: 3060, 2975, 2935, 1675, 1590, 1500, 1460, 1450, 1260, 1115, 685 cm^{-1}.

^1H nmr: δ 3.87 (3H, s, OCH_3), 4.40 (2H, s, CH_2Br), 6.95 (2H, m, [J=8.9, J=2.8, J=2.0](2x), ($C\underline{H})_2COCH_3$), 7.96 (2H, m, [J=8.9, J=2.8, J=2.0](2x), $(CH)_2CCO$) ppm.

^{13}C nmr: δ 30.78 (CH_2Br), 55.48 (OCH_3), 113.94(2x) (($\underline{C}H)_2COCH_3$), 126.76 ($\underline{C}CO$), 131.23(2x) (($\underline{C}H)_2CCO$), 163.99 ($\underline{C}OCH_3$), 189.77 (CO) ppm.

α-ACETOXY-4-METHOXYACETOPHENONE (17)

To a solution of 32.4 g (141.2 mmol) **16** in 200 ml of dry ethanol, 11.6 g (141.2 mmol) of sodium acetate and 2.2 g (14.5 mmol) of sodium iodide were added in an inert atmosphere. After refluxing for 4.5 h, the ethanol was evaporated *in vacuo* and 200 ml of water was added to the residue. The aqueous solution was extracted with ether (3 x 100 ml). The combined organic layers were washed with saturated brine (2 x 100 ml), dried with anhydrous magnesium sulfate and evaporated *in vacuo*. The crude product was crystallized from

chloroform/petroleum ether 40-60°C (1/8) affording pure **17**. Yield 19.6 g, 94.1 mmol, (67%); pale yellow crystals, mp: 55-56°C (lit. 15, 58-59°C).
ms: m/z 209 (2), 208 (M^+, 8), 135 (100), 107 (11), 77 (15), 49 (35), 18 (36).
IR: 3020, 2980, 2940, 1735, 1690, 1665, 1580, 1510, 1285, 1255, 1225, 1185 cm^{-1}.
^1H nmr: δ 2.23 (3H, s, CH_3CO), 3.87 (3H, s, CH_3O), 5.30 (2H, s, CH_2O), 6.95 (2H, m, [J=8.9, J=2.8, J=2.0](2x), ($\underline{C}H)_2COCH_3$), 7.89 (2H, m, [J=8.9, J=2.8, J=2.0](2x), ($\underline{C}H)_2CCO$) ppm.
^{13}C nmr: δ 20.56 (CH_3), 55.48 (OCH_3), 65.70 (CH_2O), 114.00(2x) ($(\underline{C}H)_2COCH_3$), 127.17 ($\underline{C}CO$), 130.00(2x) ($(\underline{C}H)_2CCO$), 163.99 ($\underline{C}OCH_3$), 170.41 ($CH_2O\underline{C}O$), 190.53 ($CH_2\underline{C}O$) ppm.

1'-(4-METHOXYPHENYL)-1',2'-ETHANEDIOL (18)
17.9 g (471.1 mmol) $LiAlH_4$ was suspended in 250 ml of dry ether in an inert atmosphere and stirred for 3 h at room temperature. The suspension was heated until reflux. Subsequently a solution of 19.6 g (94.1 mmol) **17** in 50 ml of dry ether was added dropwise in 2 h. An additional reflux period of 2 h was followed by stirring overnight at room temperature. The excess of $LiAlH_4$ was neutralized by addition of 500 ml of ether, saturated with water. Subsequently, 20 ml of water and 80 ml of sulfuric acid/ water (1/2) were added. After vigorous stirring for 10 min, the suspension was filtered over Celite 545. The organic layer was separated and the water layer was extracted with ethyl acetate (2 x 100 ml). The combined organic layers were washed with saturated brine (2 x 100 ml), dried with anhydrous magnesium sulfate and evaporated *in vacuo*. After recrystallization from chloroform/petroleum ether 40-60°C (2/3), pure 1'-(4-methoxyphenyl)-1',2'-ethanediol was obtained. Yield: 9.7 g, 57.7 mmol, (61%); white crystals, mp: 75-76°C (lit. 9, 76-77.5°C).
ms: m/z 169 (2), 168 (M^+, 14), 137 (100), 109 (35), 94 (28), 77 (32), 18 (25).
IR: 3540-3100, 2960, 2940, 1610, 1585, 1510, 1460, 1245, 1180, 1085, 1030 cm^{-1}.
^1H nmr: δ 3.5-3.7 (2H, m, $C\underline{H}_2OH$), 3.77 (3H, s, OCH_3) 4.69 (1H, dd, J_{cis}=4.1, J_{trans}=6.9, $C\underline{H}OH$), 6.84 (2H, d(2x), J=8.2(2x), ($C\underline{H})_2COCH_3$), 7.22 (2H, d(2x), J=8.2(2x), ($C\underline{H})_2CCHOH$) ppm.
^{13}C nmr: δ 55.19 (OCH_3), 67.92 (CH_2OH), 74.23 (CHOH), 113.79(2x) ($(\underline{C}H)_2COCH_3$), 127.28(2x) ($(\underline{C}H)_2CCHOH$), 132.57 ($\underline{C}CHOH$), 159.17 ($\underline{C}OCH_3$) ppm.

1'-(4-METHOXYPHENYL)-[2'-[(1,1-DIMETHYLETHYL)DIMETHYLSILYL]OXY]ETHANOL (19)
This compound was synthesized on a 59.4 mmol scale in analogy to compound **9**, using pure **18** as the starting material. Reaction time: 1 h. Purification: flash column chromatography (10% triethylamine in petroleum ether 40-60°C). Yield: 12.4 g, 49.9 mmol, (84%); colourless oil.
ms: m/z 265 ($M+H-H_2O)^+$, 62), 207 (68), 192 (65), 137 (60), 121 (35), 109 (64), 75 (100).
IR: 3600-3260, 3000, 2950, 2920, 1610, 1585, 1510, 1460, 1250, 1100, 1060 cm^{-1}.
^1H nmr: δ 0.06(2x) (6H, s(2x), $Si(CH_3)_2$), 0.91(3x) (9H, s(3x), $C(CH_3)_3$), 3.53 (1H, dd, J_{trans}=8.3, J_{gem}=-10.3, HC$\underline{H}$OSi), 3.71 (1H, dd, J_{cis}=3.8, J_{gem}=-10.3, $\underline{H}$CHOSi), 3.76 (3H, s, OCH_3), 4.66 (1H, dd, J_{cis}=3.8, J_{trans}=8.3, $C\underline{H}OH$), 6.85 (2H, d(2x), J=8.9(2x), ($C\underline{H})_2COCH_3$), 7.27 (2H, d(2x), J=8.9(2x), ($C\underline{H})_2CCHOH$) ppm.
^{13}C nmr: δ -5.55(2x) ($Si(CH_3)_2$), 18.14 ($\underline{C}(CH_3)_3$), 25.72(3x) ($C(\underline{C}H_3)_3$), 54.93 (OCH_3), 68.82 (CH_2OSi), 73.76 (CHOH), 113.44(2x) ($(\underline{C}H)_2COCH_3$), 127.25(2x) ($(\underline{C}H)_2CCHOH$), 132.42 ($\underline{C}CHOH$), 158.96 ($\underline{C}OCH_3$) ppm.

1'-(4-METHOXYPHENYL)-[1'-[TETRAHYDROPYRANYL]OXY]-[2-[(1,1-DIMETHYLETHYL)DIMETHYLSILYL]OXY]ETHANE (20)
This compound was synthesized on a 49.9 mmol scale in analogy to compound **10**, using pure **19**. Reaction time: overnight. Purification: flash column chromatography (10% triethylamine in petroleum ether 40-60°C). Yield: 16.4 g, 44.9 mmol, (90%); colourless oil.
ms: m/z 309 ($(M-C_4H_9)^+$, 2), 265 (22), 251 (40), 159 (16), 137 (31), 85 (100), 67 (21), 57 (22).
IR: 2930, 1610, 1585, 1510, 1460, 1250, 1120 cm^{-1}.
^1H nmr: δ 0.03(2x) (6H, s(2x), $Si(CH_3)_2$, *isomer 1/2*), 0.04(2x) (6H, s(2x), $Si(CH_3)_2$, *isomer 1/2*), 0.89(3x) (9H, s(3x), $C(CH_3)_3$, *isomer 1/2*), 0.90(3x) (9H, s(3x), $C(CH_3)_3$, *isomer 1/2*), 1.4-2.0 (12H, m, $(CH_2)_3$, *isomer 1+2*), 3.2-4.1 (8H, m, [CH_2O, CH_2OSi], *isomer 1+2*), 3.78(2x) (6H, s(2x), OCH_3, *isomer 1+2*), 4.5 (1H, t, OCHO, *isomer 1/2*), 4.7-4.8 (2H, m, CHO, *isomer 1+2*), 5.1 (1H, t, OCHO, *isomer 1/2*), 6.87(4x)

(d(4x), J=8.2(4x), (C<u>H</u>)$_2$COCH$_3$), 7.26(2x) (d(2x), J=8.2(2x), (C<u>H</u>)$_2$CCHOH, *isomer 1/2*), 7.32(2x) (d(2x), 2H, J=8.9(2x), (C<u>H</u>)$_2$CCHOH, *isomer 1/2*) ppm.
^{13}C nmr δ -5.57(2x), -5.49(2x) (Si(CH$_3$)$_2$, *isomer 1+2*), 18.14, 18.25, 18.78, 19.04, 30.49(2x) ((CH$_2$)$_3$, *isomer 1+2*), 19.30(2x) (<u>C</u>(CH$_3$)$_3$, *isomer 1+2*), 25.43(3x), 25.75(3x) (C(<u>C</u>H$_3$)$_3$, *isomer 1+2*), 54.98(2x) (OCH$_3$, *isomer 1+2*), 61.20, 61.67 (CH$_2$O, *isomer 1+2*), 67.71, 68.39 (CH$_2$OSi, *isomer 1+2*), 77.64, 78.69 (CHO, *isomer 1+2*), 94.23, 98.96 (OCHO, *isomer 1+2*), 113.32(2x), 113.47(2x) ((<u>C</u>H)$_2$COCH$_3$, *isomer 1+2*), 127.17, 127.25 ((<u>C</u>H)$_2$CCHO, *isomer 1/2*), 127.66, 128.48 ((<u>C</u>H)$_2$CCHO, *isomer 1/2*), 131.49, 132.71 (<u>C</u>CHO, *isomer 1+2*), 158.70, 159.11 (<u>C</u>OCH$_3$, *isomer 1+2*) ppm.

2'-(4-METHOXYPHENYL)-[2'-[TETRAHYDROPYRANYL]OXY]ETHANOL (21)

This compound was synthesized on a 44.9 mmol scale in analogy to compound **11**, using pure **20**. Reaction time: overnight. Purification: flash column chromatography (10% triethylamine and 30% petroleum ether 40-60°C in ether). Yield: 10.5 g, 41.5 mmol, (92%); colourless oil.
ms: m/z 253 ((M+H)$^+$, 3), 186 (13), 168 (25), 151 (100), 120 (31), 102 (41).
IR: 3600-3200, 2940, 1610, 1580, 1505, 1455, 1245, 1200, 1115, 1030 cm^{-1}.
^{1}H nmr: δ 1.4-1.9 (12H, m, (CH$_2$)$_3$, *isomer 1+2*), 3.2-4.1 (8H, m, [CH$_2$O, C<u>H</u>$_2$OH], *isomer 1+2*), 3.76 (6H, s(2x), OCH$_3$, *isomer 1+2*), 4.5 (1H, t, OCHO, *isomer 1/2*), 4.65 (1H, dd, J_{cis}=4.3, J_{trans}=7.8, CHO, *isomer 1/2*), 4.76 (1H, dd, J_{cis}=4.3, J_{trans}=7.8, CHO, *isomer 1/2*), 4.9 (1H, t, OCHO, *isomer 1/2*), 6.85 (d(4x), 4H, J=8.9(4x), (C<u>H</u>)$_2$COCH$_3$, *isomer 1+2*), 7.23 (d(2x), 2H, J=8.9(2x), (C<u>H</u>)$_2$CCHO, *isomer1/2*), 7.29 (d(2x), 2H, J=8.2(2x), (C<u>H</u>)$_2$CCHO), *isomer 1/2*) ppm.
^{13}C nmr: δ 19.04, 19.83, 25.02(2x), 30.28, 30.66 ((CH$_2$)$_3$, *isomer 1+2*), 54.87(2x) (OCH$_3$, *isomer 1+2*), 61.99, 63.07 (CH$_2$O, *isomer 1+2*), 66.28, 67.01 (CH$_2$OH, *isomer 1+2*), 79.13, 79.28 (CHO, *isomer 1+2*), 96.83, 98.67 (OCHO, *isomer 1+2*), 113.32(2x), 113.53(2x) ((<u>C</u>H)$_2$COCH$_3$, *isomer 1+2*), 127.60(2x), 127.81(2x) ((<u>C</u>H)$_2$CCHO, *isomer 1+2*), 130.49, 131.93 (<u>C</u>CHO, *isomer 1+2*), 158.67, 159.02 (<u>C</u>OCH$_3$, *isomer 1+2*) ppm.

2'-(4-METHOXYPHENYL)-[[2'-[TETRAHYDROPYRANYL]OXY]ETHOXY]METHYLDIPHENYL-PHOSPHINE OXIDE (22)

This phosphine oxide was synthesized on a 41.4 mmol scale in analogy to compound **13**, using pure **21**. Reaction time: overnight. Purification: flash column chromatography (5% methanol and 10% triethylamine in ether). Yield: 10.8 g, 23.2 mmol, (63%); colourless oil.
ms: m/z 468 (18), 467 ((M+H)$^+$, 61), 391 (16), 383 (100), 365 (76), 192 (13), 164 (48), 136 (19), 120 (40).
^{1}H nmr: δ 1.4-1.9 (12H, m, (CH$_2$)$_3$, *isomer 1+2*), 3.2-3.8 (8H, m, [OCH$_2$, CH$_2$C<u>H</u>$_2$O], *isomer 1+2*), 3.79 (6H, s(2x), OCH$_3$, *isomer 1+2*), 4.1-4.3 (4H, m, PCH$_2$, *isomer 1+2*), 4.4 (1H, t, OCHO, *isomer 1/2*), 4.7 (1H, t, OCHO, *isomer 1/2*), 4.8-4.9 (2H, m, CH$_2$C<u>H</u>O, *isomer 1+2*), 6.83 (4H, d(4x), J=8.9(4x), (C<u>H</u>)$_2$COCH$_3$, *isomer 1+2*), 7.16 (2H, d(2x), J=8.2(2x), (C<u>H</u>)$_2$CCHO, *isomer 1/2*), 7.23 (2H, d(2x), J=8.2(2x), (C<u>H</u>)$_2$CCHO,
isomer 1/2), 7.4-7.6 (12H, m, Ph$_2$PO, *isomer 1+2*), 7.8-7.9 (8H, m, Ph$_2$PO, *isomer 1+2*) ppm.
^{13}C nmr: δ 18.46, 23.86, 25.26, 27.71, 29.08, 30.37 ((CH$_2$)$_3$, *isomer 1+2*), 54.93(2x) (OCH$_3$, *isomer 1+2*), 65.79, 67.54 (CH$_2$<u>C</u>H$_2$O, *isomer 1+2*), 69.51(2x) (d(2x), $^1J_{CP}$=89(2x), PCH$_2$ *isomer 1+2*), 75.62(2x) (CHO, *isomer 1+2*), 77.23(2x) (d(2x), $^3J_{CP}$=10(2x), OCH$_2$, *isomer 1+2*), 95.87, 98.54 (OCHO, *isomer 1+2*), 113.21(2x), 113.42(2x) ((<u>C</u>H)$_2$COCH$_3$, *isomer 1+2*), 128.16(2x), 129.76(2x) ((<u>C</u>H)$_2$CCHO, *isomer 1+2*), 129.88(8x) (d(8x), $^2J_{PC}$=8(8x), Ph$_2$PO(C_{ortho}), *isomer 1+2*), 130.00(2x), 130.99(2x) (d(4x), $^1J_{CP}$=100(4x), Ph$_2$PO(C_{ipso}), *isomer 1+2*), 130.29, 130.38 (<u>C</u>CHO, *isomer 1+2*), 131.87(8x) (d(8x), $^3J_{CP}$=11(8x), Ph$_2$PO(C_{meta}), *isomer 1+2*), 132.51(4x) (Ph$_2$PO(C_{para}), *isomer 1+2*), 158.85, 159.29 (<u>C</u>OCH$_3$, *isomer 1+2*) ppm.
^{31}P nmr: δ 27.50, 27.44 (*isomer 1+2*) ppm.

[2'-HYDROXY-2'-(4-METHOXYPHENYL)ETHOXY]METHYLDIPHENYLPHOSPHINE OXIDE (23)

This phosphine oxide was synthesized on a 23.0 mmol scale in analogy to phosphine oxide **14**, using pure phosphine oxide **22**. Reaction time: 2.5 h. Purification: flash column chromatography (5% methanol and 10%

triethylamine in ether). Yield: 8.2 g, 21.4 mmol, (93%); colourless oil.
ms: m/z 384 (2), 383 ($(M+H)^+$, 100), 365 (86), 233 (47), 110 (25).
IR: 3500-3160, 3060, 3010, 1610, 1590, 1510, 1485, 1450, 1245, 1175, 1120, 1070, 1030 cm^{-1}.
^1H nmr: δ 3.6-3.7 (2H, m, OCH_2), 3.75 (3H, s, OCH_3), 4.30 (2H, d, $^1J_{HP}$=5.5, PCH_2), 4.79 (1H, dd, J_{cis}=4.5, J_{trans}=7.2, CHOH), 6.80 (2H, d(2x), J=8.2(2x), $(CH)_2COCH_3$), 7.20 (2H, d(2x), J=8.2(2x), $(CH)_2CCHOH$), 7.4-7.5 (6H, m, Ph_2PO), 7.6-7.8 (4H, m, Ph_2PO) ppm.
^{13}C nmr: δ 55.01 (OCH_3), 69.38 (d, $^1J_{CP}$=88, PCH_2), 71.80 (CHOH), 79.34 (d, $^3J_{CP}$=9, OCH_2), 113.41(2x) ($(CH)_2COCH_3$), 127.28(2x) ($(CH)_2CCHOH$), 128.38(4x) (d(4x), $^3J_{CP}$=13(4x), $Ph_2PO(C_{meta})$), 130.49(2x) (d(2x),
$^1J_{CP}$=100(2x), $Ph_2PO(C_{ipso})$), 131.17(4x) (d(4x), $^2J_{CP}$=9(4x), $Ph_2PO(C_{ortho})$), 132.01(2x) ($Ph_2PO(C_{para})$), 132.74 (CCHOH), 158.79 ($COCH_3$) ppm.
^{31}P nmr: δ 27.43 ppm.

[2'-[[(1,1-DIMETHYLETHYL)DIMETHYLSILYL]OXY]-2'-(4-METHOXYPHENYL)ETHOXY]-METHYLDIPHENYLPHOSPHINE OXIDE (24)
This phosphine oxide was synthesized on a 21.4 mmol scale in analogy to phosphine oxide **15**, using pure phosphine oxide **23**. Reaction time: 2.5 h. Purification: flash column chromatography (5% methanol and 10% triethylamine in ether). Yield: 10.4 g, 21.0 mmol, (98%); colourless oil.
ms: m/z 498 (13), 497 ($(M+H)^+$, 27), 365 (100).
IR: 3060, 1610, 1580, 1505, 1460, 1245, 1180, 1120 cm^{-1}.
^1H nmr: δ 0.01, 0.24 (6H, s(2x), $Si(CH_3)_2$), 1.00 (9H, s(3x), $C(CH_3)_3$), 4.04 (3H, s, OCH_3), 3.6-4.0 (2H, m, OCH_2), 4.3-4.5 (2H, m, PCH_2), 4.88 (1H, m, CHOSi), 6.98 (2H, d(2x), J=8.2(2x), $(CH)_2COCH_3$), 7.33 (2H, d(2x), J=8.2(2x), $(CH)_2CHO$), 7.4-7.5 (6H, m, Ph_2PO), 7.7-7.8 (4H, m, Ph_2PO) ppm.
^{13}C nmr: δ -5.34, -5.17 ($Si(CH_3)_2$), 17.73 ($C(CH_3)_3$), 25.40(3x) ($C(CH_3)_3$), 54.66 (OCH_3), 69.55 (d, $^1J_{CP}$=88, PCH_2), 73.09 (CHOSi), 79.64 (d, $^3J_{CP}$=10, OCH_2), 113.03(2x) ($(CH)_2COCH_3$), 127.02(2x) ($(CH)_2CCHO$), 127.98(4x) (d(4x), $^3J_{CP}$=12(4x), $Ph_2PO(C_{meta})$), 131.01(4x) (d(4x), $^2J_{CP}$=10(4x), $Ph_2PO(C_{ortho})$), 130.87(2x) (d(2x), $^1J_{CP}$=100(2x), $Ph_2PO(C_{ipso})$), 131.55(2x) ($Ph_2PO(C_{para})$), 133.50 (CCHO), 158.53 ($COCH_3$) ppm.
^{31}P nmr: δ 28.56 ppm.

Enol ether synthesis by the Horner-Wittig reaction

General procedure for the synthesis of polyenol ethers of (methyl/phenyl/4-methoxyphenyl)glycol
The procedure used was analogous to the one described for the synthesis of 3'-(polyenyloxy)-1',2'-propanediols[4]. In this case, phosphine oxides **7/15/24** or ([2'-[[(1,1-dimethylethyl)dimethylsilyl]oxy]-ethoxy]methyldiphenyl-phosphine oxide (**25**)[13]were used as the starting materials. Furthermore, instead of 2.2 equiv of TBAF.$3H_2O$, 1.1 equiv was used. The eluent used in the flash column chromatography purification of the enol ethers is specified for each enol ether.

2'-(1*E/Z*-DODECAENYLOXY)ETHANOL (26)
Starting aldehyde: undecanal, which is commercially available. Starting phosphine oxide: **25**. Yield: 2.5 g, 11.0 mmol, (55%); white semi-solid; eluent: 2% methanol and 10% triethylamine in ether. *E/Z*-ratio 1:1.
ms: m/z 229 (1), 228 (M^+, 9), 111 (11), 101 (64), 97 (18), 57 (100), 45 (48). Exact mass: 228.2090 ($C_{14}H_{28}O_2$ requires 228.2090).
^1H nmr: δ 0.87 (6H, t(2x), J=6.2(2x), CH_3, *E+Z*), 1.2-1.4 (32H, m, $(CH_2)_8$, *E+Z*), 1.87 (2H, dt, J=6.9 and 6.2, CH_2CH, *E*), 2.05 (2H, dt, J=6.9 and 6.2, CH_2CH, *Z*), 3.76 (4H, t(2x), J=7.2(2x), CH_2OH, *E+Z*), 3.82 (4H, t(2x), J=7.2(2x), OCH_2, *E+Z*), 4.37 (1H, dt, J=7.6 and 6.6, CHCHO, *Z*), 4.79 (1H, dt, J=13.0 and 6.9, CHCHO, *E*), 5.94 (1H, d, J=6.6, CHO, *Z*), 6.22 (1H, d, J=13.0, CHO, *E*) ppm.
^{13}C nmr: δ 14.02(2x) (CH_3, *E+Z*), [22.60, 23.89, 27.56, 28.97, 29.29, 29.43, 29.58, 30.57, 31.86](2x) ($(CH_2)_9$, *E+Z*), 61.20 (CH_2OH, *E*), 61.64 (CH_2OH, *Z*), 70.14 (OCH_2, *E*), 73.06 (OCH_2, *Z*), 105.03 (CHCHO, *E*), 107.98 (CHCHO, *Z*), 144.09 (CHO, *Z*), 145.56 (CHO, *E*) ppm.

2'-(1*E/Z*,3*E*-DODECADIENYLOXY)ETHANOL (27)

Starting aldehyde: 2*E*-undecenal[16]. Starting phosphine oxide: **25**. Yield: 1.8 g, 8.0 mmol, (40%); white solid; eluent: 2% methanol and 10% triethylamine in ether. *E/Z*-ratio 1:1.

uv: λmax (EtOH) 238 nm. ε=21000 $lmol^{-1}cm^{-1}$.

ms: m/z 227 (5), 226 (M^+, 30), 127 (59), 83 (100), 55 (26), 45 (44). Exact mass: 226.1933 ($C_{14}H_{26}O_2$ requires 226.1933).

^1H nmr: δ 0.87 (6H, t(2x), J=6.5(2x), CH_3, *E+Z*), 1.1-1.4 (24H, m, $(CH_2)_6$, *E+Z*), 2.02 (4H, dt(2x), J=6.9(4x), CH_2CH, *E+Z*), 3.79 (4H, t(2x), J=6.9(2x), CH_2OH, *E+Z*), 3.89(4H, t(2x), J=6.9(2x), OCH_2, *E+Z*), 5.06 (1H, dd, J=11.0 and 6.2, CHCHO, *Z*), 5.4-5.6 (3H, m, CHCHO, *E*, $CHCH_2$, *E+Z*), 5.8-6.0 (1H, dd, CH_2CHCH, *E*), 5.92 (1H, d, J=6.2, CHO, *Z*), 6.35 (1H, dd, J=16.5 and 11.0, CH_2CHCH, *Z*), 6.48 (1H, d, J=12.4, CHO, *E*) ppm.

^{13}C nmr: δ 14.08(2x) (CH_3, *E+Z*), [22.63, 29.26, 29.46, 29.58, 31.86, 32.76, 32.91](2x) ($(CH_2)_7$, *E+Z*), 61.32 (CH_2OH, *E*), 61.79 (CH_2OH, *Z*), 70.75 (OCH_2, *E*), 73.76 (OCH_2, *Z*), 107.43 (CHCHO, *Z*), 107.72 (CHCHO, *E*), 122.44 (CH_2CHCH, *Z*), 125.50 (CH_2CHCH, *E*), 129.97 (CH_2CH, *E*), 132.01 (CH_2CH, *Z*), 143.99 (CHO, *Z*), 148.07 (CHO, *E*) ppm.

2'-(1*E/Z*,3*E*,5*E*-DODECATRIENYLOXY)ETHANOL (32)

Starting aldehyde: 2*E*,4*E*-undecadienal[16]. Starting phosphine oxide: **25**. Yield: 1.3 g, 5.8 mmol, (29%); pale yellow solid; eluent: 2% methanol and 10% triethylamine in ether. *E/Z* ratio 1:1.

uv: λmax (EtOH) 275 nm.ε=28000 $lmol^{-1}cm^{-1}$.

ms: m/z 225 (10), 224 (M^+, 66), 196 (69), 194 (100), 178 (65), 166 (76), 148 (78), 96 (71), 65 (31).

^1H nmr: δ 0.89 (6H, t(2x), J=6.2(2x), CH_3, *E+Z*), 1.2-1.5 (16H, m, $(CH_2)_4$, *E+Z*), 2.06 (4H, dt(2x), J=6.9(4x), CH_2CH, *E+Z*), 3.86 (4H, t(2x), CH_2OH, *E+Z*), 3.91 (4H, t(2x), OCH_2, *E+Z*), 5.12 (1H, dd, J=6.2 and 11.0, CHCHO, *Z*), 5.5-5.7 (3H, m, CHCHO, *E*, CH_2CH, *E+Z*), 6.00 (1H, d, J=6.2, CHO, *Z*), 6.0-6.2 (5H, m, [CH_2CHCH, $CH_2CHCHCH$], *E+Z*, CHCHCHO, *E*), 6.4-6.5 (1H, dd, CHCHCHO, *Z*), 6.56 (1H, d, J=12.4, CHO, *E*) ppm.

^{13}C nmr: δ 14.02(2x) (CH_3, *E+Z*), [22.54, 28.79, 29.35, 31.65, 32.71](2x) ($(CH_2)_5$, *E+Z*), 61.20 (CH_2OH, *E*), 61.70 (CH_2OH, *Z*), 71.01 (OCH_2, *E*), 73.90 (OCH_2, *Z*), 107.69(2x) (CHCHO, *E+Z*), 123.05, 126.44, 128.66, 130.12, 130.44, 130.67, 132.83, 134.17 ($(CH)_4$, *E+Z*), 145.47 (CHO, *Z*), 149.56 (CHO, *E*) ppm.

2'-(1*E/Z*,3*E*,5*E*,7*E*-DODECATETRAENYLOXY)ETHANOL (35)

Starting aldehyde: 2*E*,4*E*,6*E*-undecatrienal. Starting phosphine oxide: **25**. Yield: 1.5 g, 6.6 mmol, (33%); pale yellow solid; eluent: 2% methanol and 10% triethylamine in ether. *E/Z*-ratio 1:1.

uv: λmax (EtOH) 296, 307, 319 nm. ε=42000, 56000, 48000 $lmol^{-1}cm^{-1}$.

ms: m/z 223 (17), 222 (M^+, 95), 179 (13), 165 (27), 135 (26), 121 (56), 109 (45), 91 (47), 57 (100), 45 (73), 31 (79), 28 (44).

^1H nmr: δ 0.91 (6H, t(2x), J=7.0, CH_3, *E+Z*), 1.3-1.4 (8H, m, $(CH_2)_2$, *E+Z*), 2.10 (4H, dt(2x), J=6.9(4x), CH_2CH, *E+Z*), 3.83 (4H, t(2x), J=5.0(2x), CH_2OH, *E+Z*), 3.89 (4H, t(2x), J=5.0(2x), OCH_2, *E+Z*), 5.12 (1H, dd, J=6.1 and 11.2, CHCHO, *Z*), 5.6-5.8 (2H, dt(2x), CH_2CH, *E+Z*), 5.65 (1H, dd, J=10.7 and 12.4, CHCHO, *E*), 5.7-6.3 (9H, m, CHCHCHO, *E*, $(CH)_4$, *E+Z*), 6.09 (1H, d, J=6.1, CHO, *Z*), 6.4-6.5 (1H, dd, CHCHCHO, *Z*), 6.79 (1H, d, J=12.4, CHO, *E*) ppm.

^{13}C nmr: δ 13.75(2x) (CH_3, *E+Z*), [21.69, 31.03, 31.91](2x) ($(CH_2)_3$, *E+Z*), 59.62 (CH_2OH, *E*), 60.17 (CH_2OH, *Z*), 71.80 (OCH_2, *E*), 74.19 (OCH_2, *Z*), 105.87 (CHCHO, *Z*), 107.01 (CHCHO, *E*), 125.76, 127.25, 128.56, 129.58, 129.90, 130.75(2x), 131.10, 131.45(2x), 133.29, 133.99 ($(CH)_6$, *E+Z*), 147.66 (CHO, *Z*), 151.69 (CHO, *E*) ppm.

2'-(1*E/Z*,3*E*,5*E*,7*E*,9*E*-DODECAPENTAENYLOXY)ETHANOL (40)

Starting aldehyde: 2*E*,4*E*,6*E*,8*E*-undecatetraenal. Starting phosphine oxide: **25**. Yield: 1.2 g, 5.4 mmol, (27%); pale yellow solid; eluent: 2% methanol and 10% triethylamine in ether. *E/Z*-ratio 2:1.

uv: λmax (EtOH) 321, 336, 353 nm. ε=26000, 37000, 33000 $lmol^{-1}cm^{-1}$.

ms: m/z 221 (12), 220 (M^+, 100), 206 (10), 174 (16), 158 (19). Exact mass: 220.1460 ($C_{14}H_{20}O_2$ requires

220.1463).
^{1}H nmr: δ 0.97 (6H, t(2x), J=7.4(2x), CH_3, *E+Z*), 2.09 (4H, dq(2x), [J=6.9 and 7.4](2x), CH_2CH_3, *E+Z*), 3.58 (4H, t(2x), J=4.8(2x), CH_2OH, *E+Z*), 3.78 (2H, t, J=4.8, OCH_2, *E*), 3.86 (2H, t, J=4.8, OCH_2, *Z*), 5.10 (1H, dd, J=6.2 and 11.0, CHCHO, *Z*), 5.64 (1H, dd, J=10.3 and 12.4, CHCHO, *E*), 5.7-5.8 (2H, dt(2x), CH_2CH, *E+Z*), 6.0-6.4 (13H, m, CHCHCHO, *E*, $(CH)_6$, *E+Z*), 6.15 (1H, d, J=6.2, CHO, *Z*), 6.45 (1H, dd, J=15.1 and 11.0, CHCHCHO, *Z*), 6.77 (1H, d, J=12.4, CHO, *E*) ppm.
^{13}C nmr: δ 13.45(2x) (CH_3, *E+Z*), 25.31(2x) (CH_2CH_3, *E+Z*), 59.62 (CH_2OH, *E*), 60.17 (CH_2OH, *Z*), 71.91 (OCH_2, *E*), 74.25 (OCH_2, *Z*), 105.93 (CHCHO, *Z*), 107.16 (CHCHO, *E*), 126.31, 127.36, 128.68, 129.79(2x), 129.93(2x), 130.25, 131.25(2x), 131.68, 132.27, 133.14(2x), 135.86, 136.27 ($(CH)_8$, *E+Z*), 148.04 (CHO, *Z*), 152.12 (CHO, *E*) ppm.

1'-(1*E/Z*-DODECAENYLOXY)-2'-PROPANOL (44)
Starting aldehyde: undecanal, which is commercially available. Starting phosphine oxide: **7**. Yield: 3.3 g, 13.6 mmol, (68%); pale yellow oil; eluent: 2% methanol and 10% triethylamine in ether. *E/Z*-ratio 2:1.
ms: m/z 244 (9), 243 ($(M+H)^+$, 100), 185 (33), 111 (14).
^{1}H nmr: δ 0.89 (6H, t(2x), J=4.5(2x), CH_3CH_2, *E+Z*), 1.08 (3H, d, J=6.2, CH_3CH, *E*), 1.10 (3H, d, J=6.2, CH_3CH, *Z*), 1.2-1.4 (32H, m, $(CH_2)_8$, *E+Z*), 1.81 (2H, dt, J=6.9 and 6.2, CH_2CHCHO, *E*), 1.98 (2H, dt, J=6.9 and 6.2, CH_2CHCHO, *Z*), 3.4-3.7 (6H, m, [OCH_2, $CHCH_3$], *E+Z*), 4.37 (1H, dt, J=6.9 and 6.2, CHCHO, *Z*), 4.78 (1H, dt, J=6.9 and 13.0, CHCHO, *E*), 5.92 (1H, d, J=6.2, CHO, *Z*), 6.22 (1H, d, J=13.0, CHO, *E*) ppm.
^{13}C nmr: δ 14.08(2x) (CH_3CH_2, *E+Z*), 18.46 (CH_3CH, *E*), 18.60 (CH_3CH, *Z*), [22.63, 23.91, 27.56, 29.00, 29.32, 29.46, 29.61, 30.60, 31.89](2x) ($(CH_2)_9$, *E+Z*), 66.17 (CHOH, *E*), 66.55 (CHOH, *Z*), 74.28 (OCH_2, *E*), 77.26 (OCH_2, *Z*), 105.03 (CHCHO, *E*), 107.92 (CHCHO, *Z*), 144.54 (CHO, *Z*), 145.59 (CHO, *E*) ppm.

1'-(1*E/Z*,3*E*,5*E*,7*E*-DODECATETRAENYLOXY)-2'-PROPANOL (45)
Starting aldehyde: 2*E*,4*E*,6*E*-undecatrienal. Starting phosphine oxide: **7**. Yield: 1.9 g, 8.2 mmol, (41%); pale yellow solid; eluent: 2% methanol and 10% triethylamine in ether. *E/Z* ratio 1:1.
uv: λmax (EtOH) 296, 308, 320 nm. ε=33000, 44000, 39000 $lmol^{-1}cm^{-1}$.
IR: 3580-3200, 3020, 2960, 2920, 2860, 1640, 1290, 1125, 1080 cm^{-1}.
^{1}H nmr: δ 0.89 (6H, t(2x), J=6.9(2x), CH_3CH_2, *E+Z*), 1.20 (6H, d(2x), J=6.6, CH_3CH, *E+Z*), 1.2-1.5 (8H, m, $(CH_2)_2$, *E+Z*), 2.09 (4H, dt(2x), J=6.9(4x), CH_2CH_2CH, *E+Z*), 3.65 (2H, m, [J=6.6 and 3.4](2x), $CHCH_3$, *E+Z*), 3.69 (4H, d(2x), J=3.4(2x), OCH_2, *E+Z*), 5.15 (1H, dd, J=6.2 and 11.7, CHCHO, *Z*), 5.6-5.8 (3H, m, CHCHO *E*, CH_2CHCH, *E+Z*), 6.0-6.2 (11H, m, CHO, *Z*, $(CH)_5$, *E+Z*), 6.58 (1H, d, J=12.4, CHO, *E*) ppm.
^{13}C nmr: δ 13.90(2x) (CH_3CH_2, *E+Z*), 18.54(2x) (CH_3CH, *E+Z*), [22.19, 31.45, 32.50](2x) ($(CH_2)_3$, *E+Z*), 66.11(2x) (CH_3CH, *E+Z*), 75.16(2x) (OCH_2, *E+Z*), 107.92(2x) (CHCHO, *E+Z*), 128.25(2x), 128.45, 128.63, 130.06, 130.55(2x), 130.93(3x), 134.44(2x) ($(CH)_6$, *E+Z*), 149.62 (CHO, *Z*), 150.09 (CHO, *E*) ppm.

1'-(1*E/Z*,3*E*,5*E*,7*E*,9*E*-DODECAPENTAENYLOXY)-2'-PROPANOL (47)
Starting aldehyde: 2*E*,4*E*,6*E*,8*E*-undecatetraenal. Starting phosphine oxide: **7**. Yield: 0.8 g, 3.6 mmol, (18%); pale yellow solid; eluent: 2% methanol and 10% triethylamine in ether. *E/Z*-ratio 5:1.
uv: λmax (EtOH) 321, 336, 352 nm. ε=24000, 30000, 27000 $lmol^{-1}cm^{-1}$.
ms: m/z 236 (15), 235 ($(M+H)^+$, 100), 191 (67), 189 (30), 175 (65), 159 (45), 147 (35), 133 (18), 102 (40).
^{1}H nmr: δ 1.01 (6H, t(2x), J=7.6(2x), CH_3CH_2, *E+Z*), 1.20 (6H, d(2x), J=6.2(2x), CH_3CH, *E+Z*), 2.12 (4H, dq(2x), [J=6.9 and 7.6](2x), CH_2CH_3, *E+Z*), 3.61 (2H, m, [J=3.4 and 6.9](2x), $CHCH_3$, *E+Z*), 3.71 (4H, d(2x), J=3.4(2x), OCH_2, *E+Z*), 5.16 (1H, dd, J=6.2 and 11.0, CHCHO, *Z*), 5.6-5.9 (2H, m, CH_2CHCH, *E+Z*), 5.64 (1H, dd, J=12.4 and 9.6, CHCHO, *E*), 6.1-6.5 (15H, m, CHO, *Z*, $(CH)_7$, *E+Z*), 6.60 (1H, d, J=12.4, CHO, *E*) ppm.
^{13}C nmr: δ 13.52(2x) (CH_3CH_2, *E+Z*), 18.69(2x) (CH_3CH, *E+Z*), 25.87(2x) (CH_2CH_3, *E+Z*), 66.14(2x) (CH_3CH, *E+Z*), 75.28(2x) (OCH_2, *E+Z*), 108.07(2x) (CHCHO, *E+Z*), [125.30, 128.71, 128.83, 129.68, 130.93, 132.33, 132.60, 136.57](2x) ($(CH)_8$, *E+Z*), 150.47(2x) (CHO, *E+Z*) ppm.

2'-(1*E/Z*-DODECAENYLOXY)-1'-PHENYLETHANOL (48)

Starting aldehyde: undecanal, which is commercially available. Starting phosphine oxide **15**. Yield: 2.3 g, 7.8 mmol, (39%); white semi-solid; eluent: 45% petroleum ether 40-60°C and 10% triethylamine in ether. *E/Z*-ratio 1:1.

ms: m/z 306 (39), 305 ($(M+H)^+$, 100), 184 (37), 121 (21).

IR: 3600-3180, 3060, 3030, 2920, 1655, 1460, 1255, 1155, 1110 cm^{-1}.

^1H nmr: δ 0.89 (6H, t(2x), J=6.2(2x), CH_3, *E+Z*), 1.1-1.3 (32H, m, $(CH_2)_8$, *E+Z*), 1.89 (2H, dt, J=6.9 and 7.6, CH_2CH, *E*), 2.06 (2H, dt, J=6.9(2x), CH_2CH, *Z*), 3.6-3.8 (4H, m, OCH_2, *E+Z*), 4.40 (1H, dt, J=6.2 and 6.9, CHCHO, *Z*), 4.79 (1H, dt, J=7.6 and 12.4, CHCHO, *E*), 4.9-5.0 (2H, m, CHOH, *E+Z*), 5.96 (1H, d, J=6.2, CHO, *Z*), 6.26 (1H, d, J=12.4, CHO, *E*), 7.2-7.4 (10H, m, Ph, *E+Z*) ppm.

^{13}C nmr: δ 14.08(2x) (CH_3, *E+Z*), 17.90, 22.66(2x), 23.97, 25.61(3x), 27.59(2x), 29.00(2x), 29.32(2x), 29.61(3x), 30.54, 31.89 ($(CH_2)_9$, *E+Z*), 72.42 (CHOH, *E*), 72.82 (CHOH, *Z*), 74.20 (OCH_2, *E*), 77.20 (OCH_2, *Z*), 105.21 (CHCHO, *E*), 108.24 (CHCHO, *Z*), 126.17(4x), 127.87(2x), 128.33(4x) (Ph(C_{ortho}, C_{para}, C_{meta}), *E+Z*), 139.90(2x) (Ph(C_{ipso})), 144.34 (CHO, *Z*), 145.42 (CHO, *E*) ppm.

2'-(1*E/Z*,3*E*,5*E*,7*E*-DODECATETRAENYLOXY)-1'-PHENYLETHANOL (49)

Starting aldehyde: 2*E*,4*E*,6*E*-undecatrienal. Starting phosphine oxide **15**. Yield: 1.4 g, 4.7 mmol, (23%); pale yellow solid; eluent: 45% petroleum ether 40-60°C and 10% triethylamine in ether. *E/Z*-ratio 2:1.

uv: λmax (EtOH) 297, 309, 321 nm. ε=39000, 52000, 46000 $lmol^{-1}cm^{-1}$.

ms: m/z 299 (16), 298 (M^+, 80), 178 (46), 121 (89), 107 (100), 79 (92), 57 (66), 43 (48), 29 (33), 18 (28).

IR: 3600-3200, 3060, 3020, 2960, 2920, 1680, 1620, 1575, 1490, 1450, 1250, 1180, 1130 cm^{-1}.

^1H nmr: δ 0.90 (6H, t(2x), J=6.9(2x), CH_3, *E+Z*), 1.3-1.5 (8H, m, $(CH_2)_2$, *E+Z*), 2.08 (4H, dt(2x), J=6.9(4x), CH_2CH, *E+Z*), 3.7-4.0 (4H, m, OCH_2, *E+Z*), 4.95 (2H, dd(2x), [J_{cis}=3.8, J_{trans}=7.9](2x), CHOH, *E+Z*), 5.17 (1H, dd, J=6.2 and 11.3, CHCHO, *Z*), 5.6-5.8 (3H, m, CHCHO, *E*, CH_2CH, *E+Z*), 5.9-6.4 (10H, m, CHO, *Z*, CHCHCHO, *E*, $(CH)_4$, *E+Z*), 6.5-6.7 (1H, dd, CHCHCHO, *Z*), 6.60 (1H, d, J=12.4, CHO, *E*), 7.2-7.4 (10H, m, Ph, *E+Z*) ppm.

^{13}C nmr: δ 13.87(2x) (CH_3, *E+Z*), [22.17, 31.45, 32.47](2x) ($(CH_2)_3$, *E+Z*), 72.39 (CHOH, *E*), 72.85 (CHOH, *Z*), 74.96 (OCH_2, *E*), 77.85 (OCH_2, *Z*), 107.98 (CHCHO, *Z*), 108.10 (CHCHO, *E*), 124.71, 126.11(4x), 128.13(3x), 128.45(4x), 128.74(2x), 130.17, 130.52(2x), 130.87, 130.99(2x), 132.19, 134.47 ($(CH)_6$, *E+Z*, Ph(C_{ortho}, C_{meta}, C_{para}), *E+Z*), 139.55(2x) (Ph(C_{ipso}), *E+Z*), 145.77 (CHO, *Z*), 149.85 (CHO, *E*) ppm.

2'-(1*E/Z*,3*E*,5*E*,7*E*,9*E*-DODECAPENTAENYLOXY)-1'-PHENYLETHANOL (52)

Starting aldehyde: 2*E*,4*E*,6*E*,8*E*-undecatetraenal. Starting phosphine oxide **15**. Yield: 1.1 g, 3.7 mmol, (19%); pale yellow solid; eluent: 10% triethylamine in ether. *E/Z*-ratio 3:1.

uv: λmax (EtOH) 322, 337, 354 nm. ε=44000, 62000, 56000 $lmol^{-1}cm^{-1}$.

ms: m/z 298 (6), 297 ($(M+H)^+$, 32), 207 (34), 193 (65), 175 (33), 156 (100), 118 (18).

^1H nmr: δ 1.00 (6H, t(2x), J=7.6(2x), CH_3, *E+Z*), 2.11 (4H, dq(2x), [J=6.9 and 7.6](2x), CH_2CH_3, *E+Z*), 3.7-3.9 (4H, m, OCH_2, *E+Z*), 4.94 (2H, dd(2x), [J_{cis}=3.8, J_{trans}=7.9](2x), CHOH, *E+Z*), 5.16 (1H, dd, J=6.2 and 11.0, CHCHO, *Z*), 5.6-5.8 (3H, m, CHCHO, *E*, CH_2CH, *E+Z*), 6.0-6.2 (13H, m, CHCHCHO, *E*, $(CH)_6$, *E+Z*), 6.08 (1H, d, J=6.2, CHO, *Z*), 6.5-6.7 (1H, dd, CHCHCHO, *Z*), 6.59 (1H, d, J=12.4, CHO, *E*), 7.2-7.4 (10H, m, Ph, *E+Z*) ppm.

^{13}C nmr: δ 13.43(2x) (CH_3, *E+Z*), 25.55 (CH_3CH_2, *Z*), 25.78 (CH_3CH_2, *E*), 72.30 (CHOH, *E*), 72.80 (CHOH, *Z*), 75.04 (OCH_2, *E*), 77.93 (OCH_2, *Z*), 107.86 (CHCHO, *Z*), 108.16 (CHCHO, *E*), 126.09(6x), 127.98(2x), 128.39(6x), 128.74(2x), 129.62(2x), 130.90(3x), 132.28(2x), 132.57, 132.71, 136.45 ($(CH)_8$, *E+Z*, Ph(C_{ortho}, C_{meta}, C_{para}), *E+Z*), 139.58(2x) (Ph(C_{ipso}), *E+Z*), 146.18 (CHO, *Z*), 150.26 (CHO, *E*) ppm.

2'-(1*E/Z*,3*E*,5*E*,7*E*,9*E*-DODECAPENTAENYLOXY)-1'-(4-METHOXYPHENYL)ETHANOL (53)

Starting aldehyde: 2*E*,4*E*,6*E*,8*E*-undecatetraenal. Starting phosphine oxide **24**. Yield: 1.1 g, 3.4 mmol, (17%); pale yellow solid; eluent: 10% triethylamine in ether. *E/Z*-ratio 1:2.

uv: λmax (EtOH) 320, 337, 354 nm. ε=25000, 31000, 27000 $lmol^{-1}cm^{-1}$.
ms: m/z 328 (2), 327 ($(M+H)^+$, 7), 207 (26), 193 (29), 191 (39), 186 (61), 168 (51), 151 (100).
^1H nmr: δ 1.00 (6H, t(2x), J=7.6(2x), CH_3, *E+Z*), 2.12 (4H, dq(2x), [J=6.9 and 7.6](2x), $C\underline{H}_2CH_3$, *E+Z*), 3.7-3.9 (4H, m, OCH_2, *E+Z*), 3.79 (6H, s(2x), OCH_3, *E+Z*), 4.78 (1H, dd, J_{cis}=4.1, J_{trans}=8.2, C<u>H</u>OH, *E*), 4.80 (1H, dd, J_{cis}=4.1, J_{trans}=8.2, C<u>H</u>OH, *Z*), 5.16 (1H, dd, J=6.2 and 11.7, C<u>H</u>CHO, *Z*), 5.6-5.8 (3H, m, C<u>H</u>CHO, *E*, $CH_2C\underline{H}$, *E+Z*), 6.0-6.2 (13H, m, C<u>H</u>CHCHO, *E*, $(CH)_6$, *E+Z*), 6.02 (1H, d, J=6.2, CHO, *Z*), 6.6-6.8 (1H, dd, C<u>H</u>CHCHO, *Z*), 6.62 (1H, d, J=12.4, CHO, *E*), 6.89 (4H, d(4x), J=8.2(4x), $(C\underline{H})_2COCH_3$, *E+Z*), 7.30 (4H, d(4x), J=8.2(4x), $(C\underline{H})_2CCHOH$, *E+Z*) ppm.
^{13}C nmr: δ 13.43 (CH_3, *Z*), 14.34 (CH_3, *E*), 25.78 ($CH_3\underline{C}H_2$, *Z*), 26.25 ($CH_3\underline{C}H_2$, *E*), 53.96 (OCH_3, *E*), 55.13 (OCH_3, *Z*), 67.95 (CHOH, *E*), 71.89 (CHOH, *Z*), 75.01 (OCH_2, *E*), 77.20 (OCH_2, *Z*), 108.07(2x) (<u>C</u>HCHO, *E+Z*), 113.70(2x) ($(\underline{C}H)_2COCH_3$, *E*), 113.82(2x) ($(\underline{C}H)_2COCH_3$, *Z*), 127.22(2x) ($(\underline{C}H)_2CCHOH$, *E*), 127.37(2x) ($(\underline{C}H)_2CCHOH$, *Z*), 128.63(2x), 128.80(2x), 129.59(2x), 130.85(2x), 130.90(2x), 131.72(2x), 132.25(2x), 132.57, 132.74, 133.27, 136.48 ($(CH)_8$, *E+Z*, <u>C</u>HOH, *E+Z*), 150.32 (CHO, *Z*), 150.38 (CHO, *E*), 159.08 ($\underline{C}OCH_3$, *E*), 159.32 ($\underline{C}OCH_3$, *Z*) ppm.

General procedure for the synthesis of 1'-(1-alkenyloxy)propanes
In an inert atmosphere, lithium diisopropylamide (22.0 mmol) was added at -50°C to a solution of propoxymethyldiphenylphosphine oxide (**54**)[13] (5.5 g, 20.0 mmol) in dry THF (100 ml). Instantaneously a deep red coloured anion appeared. After stirring for 15 min, the solution was cooled to -80°C and the required aldehyde (20.0 mmol) dissolved in dry THF (20 ml) was added dropwise. After stirring for 2 h at -80°C, the reaction mixture was quenched with saturated aqueous ammonium chloride (150 ml). The THF layer was separated and the water layer extracted with ether (3 x 150 ml). The combined organic layers were washed with saturated brine (50 ml), dried with anhydrous magnesium sulfate and evaporated *in vacuo*. Flash column chromatography afforded the pure enol ethers as mixtures of geometric isomers around the enol ether double bond.

1'-(1*E/Z*,3*E*-DODECADIENYLOXY)PROPANE (55)
Starting aldehyde: undecenal[16]. Starting phosphine oxide: **54**. Yield: 3.1 g, 13.8 mmol, (69%); colourless oil; eluent: petroleum ether 40-60°C. *E/Z*-ratio 2:1.
uv: λmax (EtOH) 241 nm. ε=24000 $lmol^{-1}cm^{-1}$.
ms: m/z 225 (3), 224 (M^+, 18), 125 (17), 83 (100), 70 (23), 55 (40).
^1H nmr: δ 0.85 (6H, t(2x), J=6.2(2x), $(CH_2)_7C\underline{H}_3$, *E+Z*), 0.95 (6H, t(2x), J=7.6(2x), $(CH_2)_2C\underline{H}_3$, *E+Z*), 1.1-1.4 (24H, m, $(CH_2)_6$, *E+Z*), 1.66 (4H, tq(2x), [J=7.6 and 6.2](2x), $OCH_2C\underline{H}_2CH_3$, *E+Z*), 2.05 (4H, dt(2x), J=6.9(4x), $C\underline{H}_2CH$, *E+Z*), 3.71 (4H, t(2x), J=6.2(2x), OCH_2, *E+Z*), 5.00 (1H, dd, J=6.2 and 10.7, C<u>H</u>CHO, *Z*), 5.4-5.6 (2H, dt(2x), $CH_2C\underline{H}$, *E+Z*), 5.47 (1H, dd, J=11.9 and 10.3, C<u>H</u>CHO, *E*), 5.7-6.0 (1H, dd, $CH_2CHC\underline{H}$, *E*), 5.84 (1H, d, J=6.2, CHO, *Z*), 6.36 (1H, dd, J=10.7 and 14.4, $CH_2CHC\underline{H}$, *Z*), 6.45 (1H, d, J=11.9, CHO, *E*) ppm.
^{13}C nmr: δ 10.22 ($(CH_2)_2\underline{C}H_3$, *Z*), 10.34 ($(CH_2)_2\underline{C}H_3$, *E*), 14.08(2x) ($(CH_2)_7\underline{C}H_3$, *E+Z*), 22.54, 23.07 ($OCH_2\underline{C}H_2$, *E+Z*), [22.69, 29.32, 29.52, 29.61, 31.92, 32.85, 32.94](2x) ($(CH_2)_7$, *E+Z*), 71.13 (OCH_2, *E*), 74.17 (OCH_2, *Z*), 106.49 (<u>C</u>HCHO, *Z*), 106.75 (<u>C</u>HCHO, *E*), 122.87 ($CH_2CH\underline{C}H$, *Z*), 126.06 ($CH_2CH\underline{C}H$, *E*), 126.06 ($CH_2\underline{C}H$, *E*), 130.99 ($CH_2\underline{C}H$, *Z*), 144.36 (CHO, *Z*), 148.72 (CHO, *E*) ppm.

1'-(1*E/Z*,3*E*,5*E*,7*E*-DODECATETRAENYLOXY)PROPANE (56)
Starting aldehyde: 2*E*,4*E*,6*E*-undecatrienal. Starting phosphine oxide: **54**. Yield: 1.8 g, 8.3 mmol, (41%); pale yellow solid; eluent: 10% triethylamine in petroleum ether 40-60°C. *E/Z*-ratio 1:1.
uv: λmax (EtOH) 297, 310, 322 nm. ε=42000, 58000, 51000 $lmol^{-1}cm^{-1}$.
^1H nmr: δ 0.89 (6H, t(2x), J=6.9(2x), $(CH_2)_3C\underline{H}_3$, *E+Z*), 0.96 (6H, t(2x), J=7.5(2x), $(CH_2)_2C\underline{H}_3$, *E+Z*), 1.2-1.4 (8H, m, $CHCH_2C\underline{H}_2CH_2$, *E+Z*, $CHCH_2CH_2C\underline{H}_2$, *E+Z*), 1.67 (4H, tq(2x), [J=7.5 and 6.9](2x), $OCH_2C\underline{H}_2$, *E+Z*), 2.09 (4H, dt(2x), [J=6.9 and 7.6](2x), $CHC\underline{H}_2$, *E+Z*), 3.73 (4H, t(2x), J=6.9(2x), OCH_2, *E+Z*), 5.10 (1H, dd, J=6.2 and 11.0, C<u>H</u>CHO, *Z*), 5.5-5.7 (3H, m, C<u>H</u>CHO, *E*, $CH_2C\underline{H}$, *E+Z*), 5.9-6.2 (11H, m, CHO, Z, $(CH)_5$, *E+Z*), 6.56 (1H, d, J=12.4, CHO, *E*) ppm.

^{13}C nmr: δ 10.25(2x) ($(CH_2)_2\underline{C}H_3$, *E+Z*), 13.93(2x) ($(CH_2)_3\underline{C}H_3$, *E+Z*), 22.22, 22.54, 23.10(2x), 31.51(2x), 32.53(2x) ($(CH_2)_3$, *E+Z*, $OCH_2\underline{C}H_2$, *E+Z*), 71.69 (OCH_2, *E*), 74.55 (OCH_2, *Z*), 107.02 (<u>C</u>HCHO, *Z*), 107.22 (<u>C</u>HCHO, *E*), 125.36, 127.90, 128.95, 129.36, 130.49, 130.67(2x), 131.20, 131.43, 131.60, 134.09, 134.55 ($(CH)_6$, *E+Z*), 146.41 (CHO, *Z*), 150.85 (CHO, *E*) ppm.

1'-(1*E/Z*,3*E*,5*E*,7*E*,9*E*-DODECAPENTAENYLOXY)PROPANE (58)

Starting aldehyde: 2*E*,4*E*,6*E*,8*E*-undecatetraenal. Starting phosphine oxide: **54**. Yield: 1.4 g, 6.4 mmol, (32%); pale yellow solid; eluent: 10% triethylamine in petroleum ether 40-60°C. *E/Z*-ratio 1:1.

uv: λmax (EtOH) 323, 337, 354 nm. ε=39000, 55000, 49000 $lmol^{-1}cm^{-1}$.

ms: m/z 219 (18), 218 (M^+, 100), 147 (14), 129 (56), 117 (37), 105 (40), 91 (71), 79 (51), 55 (33).

^1H nmr: δ 1.00 (6H, t(2x), J=7.6(2x), $CHCH_2\underline{C}H_3$, *E+Z*), 1.01 (6H, t(2x), J=7.6(2x), $(CH_2)_2\underline{C}H_3$, *E+Z*), 1.68 (4H, tq(2x), [J=7.6 and 6.9](2x), $OCH_2\underline{C}H_2$, *E+Z*), 2.12 (4H, dq(2x), J=7.6(4x), $\underline{C}H_2CH$, *E+Z*), 3.74 (4H, t(2x), J=6.9(2x), OCH_2, *E+Z*), 5.12 (1H, dd, J=6.2 and 11.0, <u>C</u>HCHO, *Z*), 5.6-5.8 (3H, m, <u>C</u>HCHO, *E*, $CH_2\underline{C}H$, *E+Z*), 6.0-6.2 (15H, m, CHO, *Z*, $(CH)_7$, *E+Z*), 6.58 (1H, d, J=12.4, CHO, *E*) ppm.

^{13}C nmr: δ 10.25 ($(CH_2)_2\underline{C}H_3$, *Z*), 10.34 ($(CH_2)_2\underline{C}H_3$, *E*), 13.55(2x) ($CHCH_2\underline{C}H_3$, *E+Z*), 22.54, 23.10, 25.90(2x), ($CH\underline{C}H_2CH_3$, *E+Z*, $OCH_2\underline{C}H_2$, *E+Z*), 71.77 (OCH_2, *E*), 74.61 (OCH_2, *Z*), 107.05 (<u>C</u>HCHO, *Z*), 107.34 (<u>C</u>HCHO, *E*), 125.91, 127.95, 129.39, 129.59, 129.74(2x), 130.44, 131.14(2x), 131.58, 132.01, 132.42, 132.90, 133.12, 136.33, 136.60 ($(CH)_8$, *E+Z*), 146.76 (CHO, *Z*), 151.20 (CHO, *E*) ppm.

Acid-catalyzed solvolysis

General procedure for solvolysis in THF/water (reaction conditions I) and methanol/water (reaction conditions II)

The conditions used were identical to those described earlier[1]. Reaction times are indicated in Tables 1-4.

2'-HYDROXYETHYL 8-HYDROXY-2*E*,4*E*,6*E*-DODECATRIENOATE (37).

Yield: 34.5 mg, 0.14 mmol, (15%); yellow oil; eluent: 5% methanol and 10% triethylamine in ether.

uv: λmax (EtOH) 300 nm. ε=36000 $lmol^{-1}cm^{-1}$.

ms: m/z 255 (1), 254 (M^+, 3), 112 (77), 83 (77), 69 (69), 57 (100), 43 (86), 31 (22), 29 (83).

IR: 3580-3160, 2960, 2930, 1675, 1615, 1260, 1125, 1010 cm^{-1}.

^1H nmr: δ 0.92 (3H, t, J=6.9, CH_3), 1.2-1.4 (4H, m, $C\underline{H}_2CH_3$, $C\underline{H}_2CH_2CH_3$), 1.56 (2H, dt, J=6.2(2x), $C\underline{H}_2CHOH$), 3.86 (2H, m, [J_{cis}=3, J_{trans}=7, J_{gem}=-12][17], $C\underline{H}_2OH$), 4.20 (1H, dt, J=6.2(2x), <u>C</u>HOH), 4.29 (2H, m, [J_{cis}=3, J_{trans}=7, J_{gem}=-12][17], $OC\underline{H}_2$), 5.91 (1H, d, J=15.1, CHCO), 5.93 (1H, dd, J=15.1 and 6.2, <u>C</u>HCHOH), 6.30 (1H, dd, J=11.0 and 14.8, <u>C</u>HCHCHCO), 6.32 (1H, dd, J=10.3 and 15.1, CHOHCHC<u>H</u>), 6.57 (1H, dd, J=14.8 and 10.3, CHOHCHCHC<u>H</u>), 7.34 (1H, dd, J=15.1 and 11.0, <u>C</u>HCHCO) ppm.

^{13}C nmr: δ 13.99 (CH_3), 22.57, 27.45, 36.88 ($(CH_2)_3$), 61.35 (CH_2OH), 66.08 (OCH_2), 72.24 (CHOH), 120.25, 129.06, 129.74, 140.42, 141.39, 145.07 ($(CH)_6$), 167.32 (CO) ppm.

2'-HYDROXYETHYL 8-METHOXY-2*E*,4*E*,6*E*-DODECATRIENOATE (39).

Yield: 20.0 mg, 0.07 mmol, (7%); yellow oil; eluent: 5% methanol and 10% triethylamine in ether.

uv: λmax (EtOH) 298 nm. ε=25000 $lmol^{-1}cm^{-1}$.

ms: m/z 269 (9), 268 (M^+, 52), 223 (35), 211 (72), 121 (44), 109 (35), 91 (45), 57 (55), 45 (100), 31 (20).

IR: 3580-3245, 2960, 2930, 1705, 1618, 1295, 1260, 1130, 1010 cm^{-1}.

^1H nmr: δ 0.88 (3H, t, J=6.9, CH_3), 1.2-1.4 (4H, m, $C\underline{H}_2CH_3$, $C\underline{H}_2CH_2CH_3$), 1.55 (2H, dt, 6.2(2x), $C\underline{H}_2CHOCH_3$), 3.27 (3H, s, OCH_3), 3.59 (1H, dt, J=6.2(2x), <u>C</u>HOCH$_3$), 3.86 (2H, m, [J_{cis}=3, J_{trans}=7, J_{gem}=-12][17], $C\underline{H}_2OH$), 4.27 (2H, m, [J_{cis}=3, J_{trans}=7, J_{gem}=-12][17], OCH_2), 5.76 (1H, dd, J=6.2 and 14.8, <u>C</u>HCHOCH$_3$), 5.91 (1H, d, J=15.3, CHCO), 6.26 (1H, dd, J=11.0 and 15.1, <u>C</u>HCHCHCO), 6.30 (1H, dd, J=10.8 and 14.8, $CH_3OCHCHC\underline{H}$), 6.58 (1H, dd, J=15.1 and 10.8, C<u>H</u>$(CH)_3CO$), 7.33 (1H, dd, J=15.3 and 11.0, <u>C</u>HCHCO) ppm.

^{13}C nmr: δ 13.99 (CH_3), 22.62, 27.39, 35.07 ($(CH_2)_3$), 56.47 (OCH_3), 61.35 ($C\underline{H}_2OH$), 66.08 (OCH_2), 81.82 (<u>C</u>HOCH$_3$), 120.33, 129.68, 131.05, 139.58, 140.25, 145.07 ($(CH)_6$), 167.26 (CO) ppm.

2'-HYDROXYETHYL 10-METHOXY-2*E*,4*E*,6*E*,8*E*-DODECATETRAENOATE (43).
Yield: 6.8 mg, 0.03 mmol, (3%); yellow oil; eluent: 10% triethylamine in ether.
uv: λmax (EtOH) 322 nm. ε=32000 $lmol^{-1}cm^{-1}$.
ms: m/z 267 (9), 266 (M^+, 30), 235 (53), 173 (46), 145 (82), 117 (100), 105 (85), 91 (78), 73 (56), 57 (44).
Exact mass: 266.1507 ($C_{15}H_{22}O_4$ requires 266.1518).
IR: 3560-3240, 2960, 2920, 1700, 1595, 1300, 1260, 1008 cm^{-1}.
^1H nmr: δ 0.89 (3H, t, J=7.4, CH_3), 1.64 (2H, dq, J=6.5 and 7.4, CH_2CH_3), 3.28 (3H, s, OCH_3), 3.54 (1H, dt, J=6.5(2x), $CHOCH_3$), 3.87 (2H, m, [J_{cis}=3, J_{trans}=7, J_{gem}=-12][17], CH_2OH), 4.30 (2H, m, [J_{cis}=3, J_{trans}=7, J_{gem}=-12][17], OCH_2), 5.68 (1H, dd, J=15.1 and 6.5, $CHCHOCH_3$), 5.91 (1H, d, J=15.3, CHCO), 6.26 (1H, dd, J=10.3 and 15.1, $CH_3OCHCHCH$), 6.30 (1H, dd, J=10.6 and 14.8, $CH_3O(CH)_4CH$), 6.38 (1H, dd, J=11.3 and 15.7, $CH(CH)_2CO$), 6.43 (1H, dd, J=14.8 and 10.3, $CH_3O(CH)_3CH$), 6.61 (1H, dd, J=15.7 and 10.6, $CH(CH)_3$), 7.36 (1H, dd, J=15.3 and 11.3, CHCHCO) ppm.
^{13}C nmr: δ 9.62 (CH_3), 28.26 (CH_2CH_3), 59.39 (OCH_3), 61.41 (CH_2OH), 66.07 (OCH_2), 83.28 ($CHOCH_3$), 119.95, 129.93, 131.63, 131.93, 136.59, 137.30, 140.99, 145.15 ($(CH)_8$), 167.39 (CO) ppm.

2'-HYDROXYPROPYL 8-HYDROXY-2*E*,4*E*,6*E*-DODECATRIENOATE (46).
Yield: 9.7 mg, 0.04 mmol, (4%); yellow oil; eluent: 10% triethylamine in ether.
uv: λmax (EtOH) 300 nm. ε=28000 $lmol^{-1}cm^{-1}$.
IR: 3560-3200, 2960, 2930, 1710, 1615, 1260, 1220, 1130 cm^{-1}.
^1H nmr: δ 0.91 (3H, t, J=7.2, CH_3CH_2), 1.23 (3H, d, J=5.5, CH_3CH), 1.3-1.5 (4H, m, $(CH_2)_2$), 1.56 (2H, dt, J=6.2(2x), CH_2CHOH), 4.0-4.2 (5H, m, OCH_2, CH_3CHOH, CH_2CHOH), 5.91 (1H, d, J=15.1, CHCO), 5.92 (1H, dd, J=6.2 and 15.5, CH_2CHOH), 6.27 (1H, dd, J=14.8 and 11.0, CHCHCHCO), 6.34 (1H, dd, J=10.7 and 15.5, $CHOHCHCH$), 6.57 (1H, dd, J=10.7 and 14.8, $CHOHCHCHCH$), 7.33 (1H, dd, J=15.1 and 11.0, CHCHCO) ppm.
^{13}C nmr: δ 13.99 (CH_3CH_2), 19.16 (CH_3CH), 22.57, 27.48, 36.91 ($(CH_2)_3$), 66.20 (CH_3CHOH), 69.58 (OCH_2), 72.24 (CH_2CHOH), 120.25, 129.06, 129.74, 140.42, 141.42, 145.07 ($(CH)_6$), 167.05 (CO) ppm.

2*E*,4*E*,6*E*-DODECATRIENAL (50)
Yield: 3.9 mg, 0.02 mmol, (3%); yellow oil; eluent: 10% triethylamine in ether.
uv: λmax (EtOH) 318 nm. ε=22000 $lmol^{-1}cm^{-1}$.
ms: m/z 179 (2), 178 (M^+, 4), 167 (17), 149 (81), 71 (86), 57 (100), 41 (90), 29 (86).
^1H nmr: δ 0.91 (3H, t, J=6.9, CH_3), 1.2-1.5 (6H, m, $(CH_2)_3$), 2.18 (2H, dt, J=6.9(2x), CH_2CH), 6.0-6.3 (3H, m, CHCHO, CH_2CH, CH_2CHCH), 6.34 (1H, dd, J=11.0 and 14.6, CHCHCHCHO), 6.65 (1H, dd, J=10.0 and 14.6, $CH_2CHCHCH$), 7.12 (1H, dd, J=11.0 and 15.1, CHCHCHO), 9.55 (1H, d, J=8.2, CHO) ppm.
^{13}C nmr: δ 13.87 (CH_3), 22.22, 30.98, 32.73(2x), $((CH_2)_4)$, 127.72, 129.71, 130.61, 142.67, 143.28, 152.42 $((CH)_6)$, 193.57 (CHO) ppm.

2'-PHENYL-2'-HYDROXYETHYL 8-HYDROXY-2*E*,4*E*,6*E*-DODECATRIENOATE (51).
Yield: 12.0 mg, 0.04 mmol, (5%); yellow oil; eluent: 10% triethylamine in ether.
uv: λmax (EtOH) 302 nm. ε=28000 $lmol^{-1}cm^{-1}$.
ms: m/z 312 ($(M-H_2O)^+$, 10), 227 (20), 149 (69), 107 (100), 85 (94), 71 (76), 57 (99), 43 (69), 29 (45), 18 (63).
IR: 3580-3160, 3060, 3020, 2960, 2935, 1685, 1615, 1490, 1450, 1300, 1260, 1130 cm^{-1}.
^1H nmr: δ 0.92 (3H, t, J=6.2, CH_3), 1.2-1.4 (4H, m, $(CH_2)_2$), 1.57 (2H, dt, J=6.2(2x), CH_2CHOH), 4.1-4.3 (1H, dt, CH_2CHOH), 4.24 (1H, dd, J_{trans}=8.1, J_{gem}=-11.4, $HCHCHOH$), 4.37 (1H, dd, J_{cis}=3.3, J_{gem}=-11.4, $HCHCHOH$), 5.00 (1H, dd, J_{cis}=3.3, J_{trans}=8.1, $PhCHOH$), 5.92 (1H, d, J=15.1, CHCO), 5.94 (1H, dd, J=6.2 and 14.8, CHCHOH), 6.29 (1H, dd, J=11.0 and 14.6, CHCHCHCO), 6.35 (1H, dd, J=10.9 and 14.8, $CHOHCHCH$), 6.57 (1H, dd, J=14.6 and 10.9, $CHOHCHCHCH$), 7.3-7.5 (6H, m, CHCHCO, Ph) ppm.
^{13}C nmr: δ 13.99 (CH_3), 22.57, 27.48, 36.88 ($(CH_2)_3$), 69.35 ($PhCHOH$), 72.27 (CH_2CHOH), 72.56 (OCH_2), 120.16, 126.14(2x), 128.19, 128.54(2x), 129.06, 129.74, 139.81, 140.48, 141.42, 145.24 ($(CH)_6$, Ph), 167.11 (CO) ppm.

PROPYL 8-HYDROXY-2*E*,4*E*,6*E*-DODECATRIENOATE (57)

Yield: 22.7 mg, 0.09 mmol, (10%); yellow oil; eluent: 10% triethylamine and 45% petroleum ether 40-60°C in ether.

uv: λmax (EtOH) 299 nm. ε=27000 $lmol^{-1}cm^{-1}$.

ms: m/z 254 (2), 253 ($(M+H)^+$, 13), 235 (23), 209 (52), 195 (100), 177 (50), 118 (25), 102 (47).

IR: 3560-3160, 2960, 2930, 1670, 1250, 1100, 1050 cm^{-1}.

^1H nmr: δ 0.94 (3H, t, J=6.2, $(CH_2)_3\underline{C}H_3$), 0.96 (3H, t, J=7.6, $(CH_2)_2\underline{C}H_3$), 1.2-1.4 (4H, m, $CH_2\underline{C}H_2CH_2CH_3$, $CH_2CH_2\underline{C}H_2CH_3$), 1.57 (2H, dt, J=6.2(2x), $\underline{C}H_2CHOH$), 1.71 (2H, tq, J=7.6 and 6.9, $OCH_2\underline{C}H_2$), 4.11 (2H, t, J=6.9, OCH_2), 4.20 (1H, dt, J=6.2(2x), $\underline{C}HOH$), 5.89 (1H, d, J=15.1, CHCO), 5.91 (1H, dd, J=6.2 and 14.4 $\underline{C}HCHOH$), 6.28 (1H, dd, J=14.8 and 11.4, $\underline{C}HCHCHCO$), 6.35 (1H, dd, J=10.7 and 14.4, $\underline{C}HCHCHOH$), 6.56 (1H, dd, J=10.7 and 14.8, $\underline{C}HCHCHCHOH$), 7.30 (1H, dd, J=11.4 and 15.1, $\underline{C}HCHCO$) ppm.

^{13}C nmr: δ 10.43 ($(CH_2)_2\underline{C}H_3$), 13.99 ($(CH_2)_3\underline{C}H_3$), 22.05, 22.57, 27.48, 36.91 ($(CH_2)_3$, $OCH_2\underline{C}H_2$), 65.93 (OCH_2), 72.30 ($\underline{C}HOH$), 121.12, 129.21, 130.00, 139.75, 140.89, 144.16 ($(CH)_6$), 167.11 (CO) ppm.

References and notes

1. Part I: Vertegaal, L.B.J; van der Steeg, M; van der Gen, A. *Tetrahedron Lett.*, **1989**, *30*, 5639.
2. Part II: Vertegaal, L.B.J; van der Gen, A. *Tetrahedron*, **1990**, *46*, 7301.3.
3. a. Kresge, A.J.; Tobin, J.B. *J. Phys. Org. Chem.*, **1991**, *4*, 587.
   b. Keeffe, J.R.; Kresge, A.J. "Kinetics and mechanisms of enolization and ketonization" in *The Chemistry of Enols*, Z. Rappoport, Ed.; Wiley: Chichester, U.K. **1990**, 399-480.
4. De Wit, P.P. "Synthesis and electrophilic properties of (polyunsaturated) enol ethers", Ph.D. Thesis, Leiden University, The Netherlands, **1987**.
5. Wollenberg, R.H. *Tetrahedron Lett.*, **1978**, *8*, 717.
6. Attempted synthesis of **7** by direct reaction of **3** with *tert*-butyldimethylsilyl (TBS)-protected bromoisopropanol was not successful. For the synthesis of compound **3** see ref. 4.
7. Attempted reaction of THP-protected 1-phenyl-2-bromoethanol with phosphine oxide **3**, which would have been analogous to the synthesis of phosphine oxide **5**, did not afford the desired product **13**.
8. Chaudhary, S.K.; Hernandez, O. *Tetrahedron Lett.*, **1979**, *2*, 99.
9. Holshouser, M.H.; Kolb, M. *Journal of Pharmaceutical Sciences*, **1986**, 75, 619.
10. This compound has been described earlier (see ref. 2).
11. Zuilhof, H.; Vertegaal, L.B.J.; van der Gen, A; Lodder, G. *J. Org. Chem.*, **1993**, *58*, 2804.
12. Vertegaal, L.B.J.; Voogd, C.E.; Mohn, G.R.; van der Gen, A. *Mutation Res*, **1992**, *281*, 93.
13. This compound has been described earlier by P.P. de Wit (see ref. 4).
14. Maksimov, V.I.; Prakhina, Z.A. *Zh. Obshch. Kim.*, **1958**, *28*, 246.
15. Tiffereau, M.M. *Comptes Rendus*, **1910**, *150*, 1182.
16. Generously donated by Quest International B.V., Naarden, The Netherlands.
17. These coupling constants (J) have been calculated, with help of the group of Prof. C. Altona, Leiden University, The Netherlands, using an nmr-simulation program.

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