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Intramolecular Palladium-catalysed Cross Coupling; a Direct Route to γ-Oxo-α,β-unsaturated Macrocycles.

Jack E. Baldwin, Robert M. Adlington and Steve H. Ramcharitar.

The Dyson Perrins Laboratory, University of Oxford, South Parks Road, Oxford, OX1 3QY.

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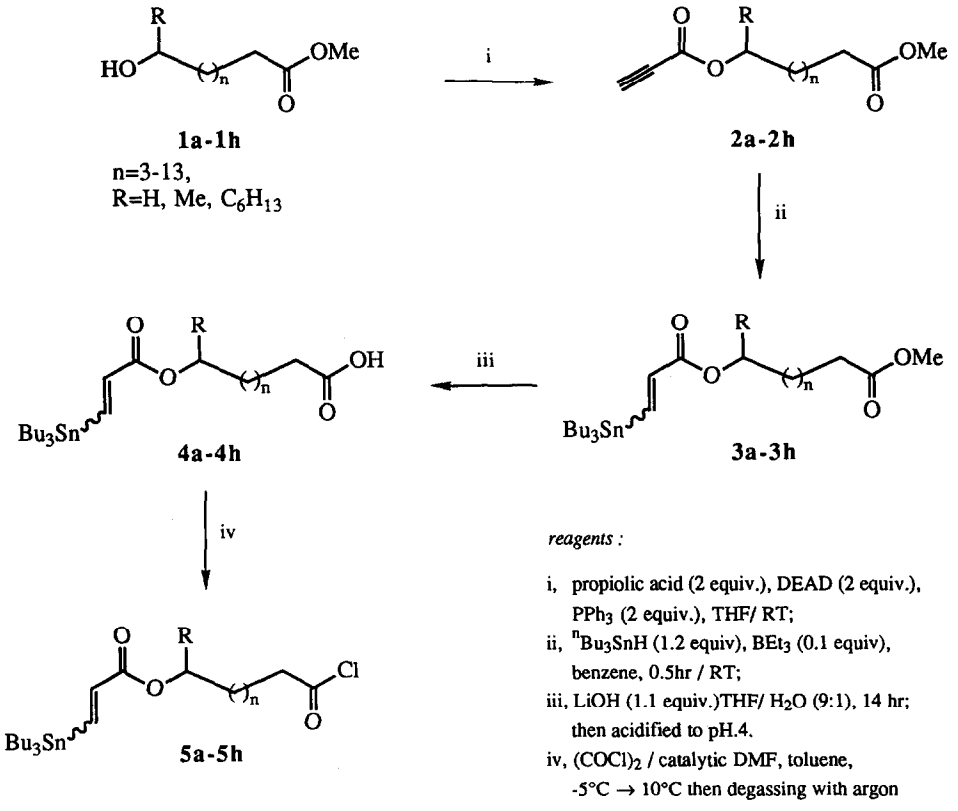
Abstract: *Intramolecular Pd^0-catalysed cross coupling of structures terminating in an acyl chloride and a β-stannylalkenoate has provided a new and an efficient route to 10-20 membered γ-oxo-α,β-unsaturated macrolides. Both the Z- and E- β-stannylalkenoates afforded identical macrocyclic products demonstrating that under the reaction conditions thermodynamic equilibration of the first formed cross coupled product was most probably occurring. The method has been used to synthesise the macrocyclic framework of the antibiotic A26771B and norpatulolide B.*

The Stille reaction[1a] which involves the palladium catalysed cross coupling of organic electrophiles and organostannanes has received much attention by virtue of its mildness and high yields. Furthermore, it has been reported to be relatively insensitive to moisture and air, tolerates a variety of functional groups on either coupling partner, and is both regio- and stereospecific[1b]. Despite these virtues the potential of the Stille reaction as a means for macrocyclisation has been largely overlooked[2].

An intramolecular Pd^0-catalysed cross coupling[3] of an entity terminating in an acid chloride and a β-stannylalkenoate represented to us a direct means to macrolides bearing the γ-oxo-α,β-unsaturated ester functionality[4] and may offer significant advantages as most of the numerous methods to synthesise such molecules demand relatively delicate macrocyclisation techniques and extensive use of protecting groups[5]. It was anticipated that such a system should promote macrocyclisation since the palladium catalyst would act as a template to assemble the ends of the molecule through oxidative addition to the acyl chloride moiety and coordination of the vinylstannane unit prior to transmetallation. Extrusion of the palladium by reductive elimination would simultaneously generate a carbon-carbon bond whilst reducing the ring size. Medium sized rings might also be accessible in such a fashion.

Suitable intramolecular precursors **5a-5h** were readily obtained by the esterification of methyl ω-hydroxy-alkanoates **1a-1h** with propiolic acid under the Mitsunobu conditions[6] to give the propiolate esters **2a-2h**. BF_3-induced hydrostannation[7] of **2a-2h** with tributyltin hydride afforded the β-stannylalkenoates **3a-3h** as a roughly 1:1 mixture of *Z*- and *E*- isomers. These were separated by column chromatography and the

desired isomer regioselectively saponified[8] with LiOH (1.1 equiv.) in THF/H_2O and acidified to pH 4 to afford the free acids **4a-4h.** The preferential cleavage of the methyl ester over the β-stannylalkenoate is both sterically and electronically favoured[9]. The acids **4a-4h** were subsequently converted to their corresponding acid chlorides **5a-5h** (Scheme 1) with oxalyl chloride and catalytic DMF[10]. In the Mitsunobu esterification reaction[6] improved yields of **2a-2h** were achieved (at the expense of the propiolic acid due to polymerisation, as observed in the unmodified version[11]) by dropwise addition of a mixture of the alcohol **1a-1h** (1 equiv.) and triphenylphosphine (2 equiv.) to a solution of propiolic acid (2 equiv.) and DEAD (2 equiv.) at room temperature. Presumably the low concentration of the activated alcohol/phosphonium intermediate formed under these reaction conditions can be driven to the propiolate ester product by the high concentration of propiolic acid present in the reaction mixture. Consequently two equivalents of acid were needed to drive the reaction to completion. The formation of the acid chlorides **5a-5h** had to be carefully controlled over the temperature range (-5→10°C) so as to avoid any possible anhydride formation and protodestannation. Degassing with argon was necessary to avoid protodestannation of the β-stannyl moiety. The acid chlorides prepared this way needed no further purification and were taken directly to the intramolecular Stille reaction.

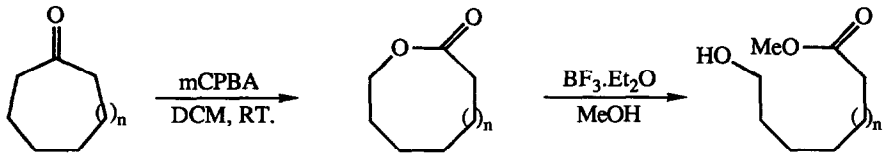


reagents :

i, propiolic acid (2 equiv.), DEAD (2 equiv.), PPh_3 (2 equiv.), THF/ RT;
ii, $^nBu_3SnH$ (1.2 equiv), BEt_3 (0.1 equiv), benzene, 0.5hr / RT;
iii, LiOH (1.1 equiv.)THF/ H_2O (9:1), 14 hr; then acidified to pH.4.
iv, $(COCl)_2$ / catalytic DMF, toluene, -5°C → 10°C then degassing with argon

Scheme 1

The methyl ω-hydroxyalkanoates **1a-1h** were synthesised from their corresponding ω-hydroxyalkyl-acids except for **1f** and **1g** which were formed by Baeyer-Villiger oxidation[12] of cyclooctanone and cyclo-heptanone to their lactones **6** and **7** respectively, followed by BF_3 mediated ester cleavage in methanol.



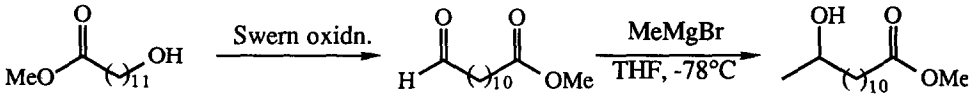
n=2
n=1

6 n=2
7 n=1

1f n=2
1g n=1

Scheme 2

The secondary methyl ω-hydroxyalkanoate **1c** (Scheme 3) was obtained by Swern oxidation[13] of methyl 12-hydroxydodecanoate to the aldehyde **8** followed by treatment with methylmagnesium bromide (1.1 equiv.).

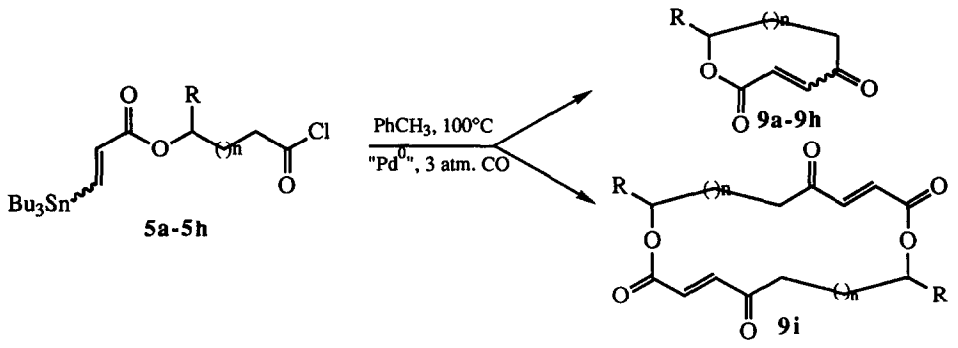


1d **8** **1c**

Scheme 3

The optimal temperature and solvent that effected the intramolecular Stille reaction was found to differ from that reported for intermolecular coupling[3] (1 atm. CO, $CHCl_3$, 65°C) and involved heating a 4mmol dm^{-3} solution of the substrate **5a-5h** and 5mol% of the catalyst *trans*- benzylchlorobis(triphenylphosphine)palladium (II) in toluene under 3 atmospheres of carbon monoxide at 100°C (Scheme 4 and Table 1)*. Toluene was found to be the best solvent for macrocyclisation since lower yields were observed in benzene or chloroform. Presumably the higher temperature (100°C) achieved in toluene maximises the entropy contribution to the free energy of activation of the reaction thus promoting macrolide formation at the expense of intermolecular coupling. It is also worth noting that polar solvents have been reported[14] to enhance the intermolecular coupling reaction by accelerating the electrophilic cleavage of the carbon-tin bond. Thus the use of chloroform (a solvent more polar than toluene) for attempted macrocyclisation may also have accelerated intermolecular coupling at the expense of the intra-molecular reaction.

* In our experiments, the presence of carbon monoxide improved the yields of macrocyclisation products; Stille has attributed this effect to suppression of decarbonylation of the acyl chloride in the intermolecular reaction[3].

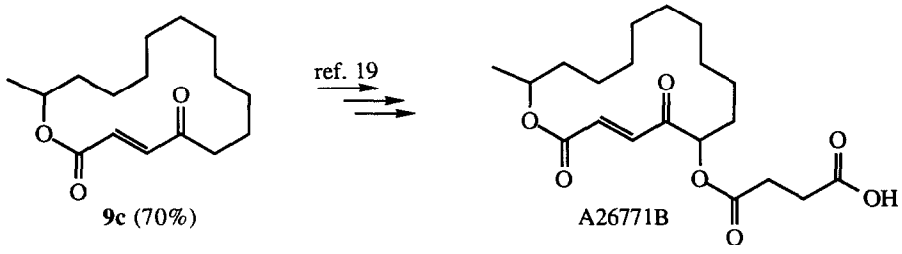


Scheme 4

from β-stannyl-alkenoyl chloride	R	n	ring size	product, yield%
E - **5a**	H	13	20	*E* - **9a**, 48%
Z - **5b**	C_6H_{13}	9	16	*E* - **9b**, 58%
E - **5c**	CH_3	9	16	*E* - **9c**, 70%
E - **5d**	H	9	16	*E* - **9d**, 53%
E - **5e**	H	7	14	*E* - **9e**, 55%
E - **5f**	H	5	12	*Z* - **9f**, 41%
E - **5g**	H	4	11	*Z* - **9g**, 32%
Z - **5h**	H	3	10, 20 (dimer)	*Z* - **9h**, 15% and **9i**, 38%
E - **5h**	H	3	20 (dimer)	*E* - **9i**, 58%

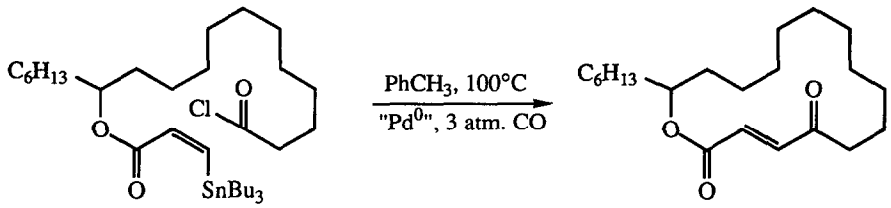
Table 1

γ-Oxo-α,β-unsaturated macrolides of ring sizes 10-20 membered were formed *via* the intra-molecular Stille reaction under the optimised conditions[15]. They were relatively stable but prolonged exposure to light resulted in isomersation of the double bond as reported by Bartlett[16]. The mechanism of the cross coupling can be described as "template driven" by the palladium catalyst, but also of prime importance is the effective molarity[17] as lower yields were observed on crude ^{1}H n.m.r. analysis of the reaction mixture both at high concentrations (10-50mmol dm^{-3}) due to competing intermolecular cross coupling and at low concentrations (2mmol dm^{-3}) where protodestannation was found to be predominant. The utility of this new method was exemplified by the synthesis (70%) of the macrolide **9c** (Scheme 5) which provides the macrocyclic framework for the 16-membered antibiotic (±)-A26771B[18].



Scheme 5

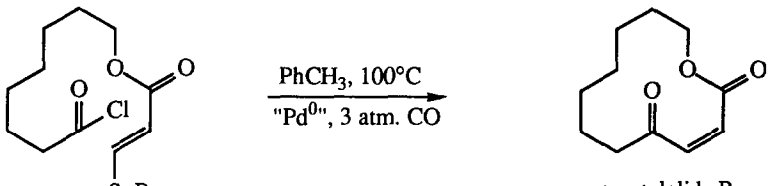
Substituents larger than methyl can also be accommodated (Scheme 6) with a comparable yield upon macrocyclisation e.g. Z-**5b**→E-**9b** (58%). This example also demonstrated an interesting feature that was not previously described in the Stille coupling reaction in that an E- product **9b** was obtained from a Z- precursor **5b**.



Z- **5b** E- **9b**, 58%

Scheme 6

This surprising result can be attributed to the fact that although the vinyl group transfers with retention of of stereochemistry at the double bond from the tin to palladium[1b], isomerisation of the α,β-unsaturated ketone product[16] takes place rapidly under the reaction conditions and ultimately the thermodynamic *trans*- configuration is observed in the coupled product. Further evidence supporting the formation of the thermodynamic product was seen with ring sizes 12- and 11-membered where the Z- double bond geometry was obtained in the products **9f** and **9g** respectively from their corresponding E- precursors. The product **9f** (Scheme 7) is the 12-membered macrolide norpatulolide B[20]. It is also worth noting that the formation of such medium ring structures in respectable yields can be attributed to the "templated driven mechanism" since 11- and 12-membered rings are difficult to cyclise by conventional cyclisation methods. These results illustrate the potential for medium ring synthesis *via* ring contraction of a larger transient palladium containing macrocycle.

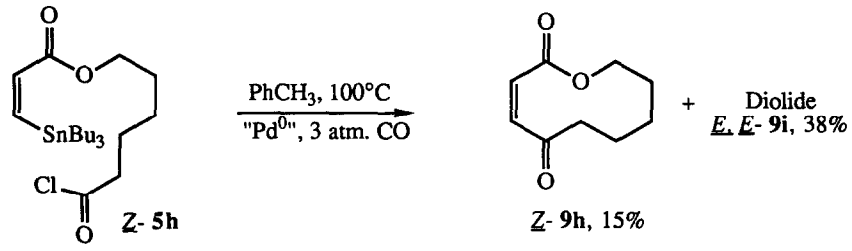


E-**5f** norpatulolide B
Z-**9f**, 41%

Scheme 7

The amount of monomeric species was found to decrease considerably when applied to smaller ring sizes and this was partly due to the competing intermolecular reaction. In the case of the E- **5h** the intermolecular coupling reaction was found to be predominant and ultimately resulted in the E, E- 20-membered dilactone **9i** after initial dimerisation. This reaction offers a potential route to macrocyclic dilactone antibiotics e.g. pyrenophorin[21]. The result obtained with Z- **5h** supports the accepted Stille coupling mechanism that a double bond is transferred with retention of geometry (Scheme 8) since the 10-membered Z- monomeric product **9h** was isolated, albeit it low yield (15%). The major product of this reaction was the E, E- dilactone **9i**, presumably formed by virtue of the fact that the construction of a 10-membered ring is a slow process and as a result, the

molecule prefers to undergo the faster intermolecular reaction; isomerisation under the reaction conditions then accounts for production of the *E, E*- dimer **9i**.



Scheme 8

In summary we have found a facile and versatile route to γ-oxo-α,β-unsaturated macrolides of ring sizes 10-20 employing palladium mediated cross coupling and have exploited it to synthesis of natural products.

EXPERIMENTAL SECTION

Infrared (IR) spectra were recorded on a Perkin-Elmer 681 spectrometer with only selected absorptions being recorded. Absorption maxima were recorded in cm^{-1}. Nuclear magnetic resonance (NMR) spectra were recorded on a Varian Gemini-200 spectrometer. Spectra were taken using $CDCl_3$ as solvent with chemical shifts quoted in parts per million (δ p.p.m.) using the residual solvent peak as an internal reference. Coupling constants (*J*) are quoted to the nearest 0.5Hz. For tin containing compounds, coupling constants for tin isotopomer satellites have not been quoted. ^{13}C spectra were recorded on a Varian Gemini-200 spectrometer, using DEPT editing where indicated; quarternary carbons were assigned from a broad band proton decoupled analysis used in combination with the DEPT programme. Mass spectra were recorded on a V.G. Micromass ZAB 1F (IBEI/EI/DCI), a V.G. 20-250 (DCI/CI) or V.G. TRIO 1 (GCMS) spectrometer, with only the major isotope peaks for stannanes (^{120}Sn) being assigned. Bulb to bulb distillation refers to distillation at reduced pressure using a horizontal Kugelrohr apparatus, the temperature quoted being that of the heating bath. Melting points were obtained using a Buchi 510 capillary melting point apparatus and are uncorrected. Microanalyses were performed in the Dyson Perrins Laboratory.

Flash chromatography was performed on silica gel (Merck-Kieselgel $60GF_{254}$ 230-400mesh). Preparative plate (p.l.c.) chromatography was carried out on glass plates (20cm x 20cm) coated with silica gel (Blend 41) and with a Kieselgel band and were pre-eluted with dichloromethane before use. Thin layer chromatography was performed on aluminium sheets pre-coated with Merck DC-Alufolien 60 F_{254} plates being visualised by either the quenching of u.v. fluorescence (λ_{max}=254nm) or by staining with 5% (w/v) potassium permanganate and 0.5% (w/v) potassium carbonate solution or 10% (w/v) ammonium molybdate in 2M sulphuric acid followed by heating.

All solvents were distilled before use; tetrahydrofuran (THF) was obtained dry and oxygen free by distillation from sodium/benzophenone ketyl. 'Petrol' refers to the fraction of light petroleum ether boiling between 40-60°C. Solvents were evaporated at 35°C or below on a Buchi R110 Rotavapor. The purity of triphenyltin hydride was regularly ascertained by comparison of the ^1H n.m.r. integration of the tin hydride and the aryl resonances. All other reagents were used as obtained from commercial sources.

General procedure for the preparation of Methyl ω-hydroxyalkanoates **1a-1h**. A solution of the secoacid in methanol (≈3ml/mmol) and 6M hydrochloric acid (3ml/100ml of methanol) were heated to reflux with stirring overnight. After evaporation of the solvent, the residue was taken up in ethyl acetate (100ml) and washed with saturated aqueous sodium bicarbonate solution (2x25ml) and brine (25ml). The organic layer was dried ($MgSO_4$), filtered and concentrated to give the spectroscopically pure methyl esters.

Methyl 16-hydroxyhexadecanoate **1a**. The general procedure yielded **1a** (1.02g, quantitative) as a white solid from 16-hydroxyhexadecanoic acid (1.0g, 3.67mmol). (m.p. 55-57°C). $\nu_{max.}$ ($CHCl_3$) 2922 (vs), 2858 (s), 1730 (s), 1462 (m), 1438 (s), 1220 (br, m) and 1030 (br, w); δ_H (200MHz) 1.15-1.40 (22H, br, s, $HOC_2H_4(C\underline{H}_2)_{11}$), 1.42-1.70 (4H, m, $OCH_2C\underline{H}_2(CH_2)_{11}C\underline{H}_2$), 2.29 (2H, t, *J* 8.0Hz, CH_2CO), 3.64 (2H, t, *J* 7.0Hz, $C\underline{H}_2OH$), 3.66 (3H, s, OCH_3); δ_C (50.4MHz, DEPT) 174.67 (C=O), 62.93 (CH_2OH), 33.97, 32.62, 29.47, 29.29, 29.10, 28.99, 25.59, 24.79 (CH_2), 51.36 (CH_3); *m/z* (C.I., NH_3) 304 (MNH_4^+, 12%), 288 (18), 287 (MH^+, 100), 267 (7), 256 (8), 255 (14), 237 (7), 112 (5), 98 (14), 87 (6), 74 (12), 69 (10), 59 (4) and 55 (6).

Methyl 12-hydroxyoctadecanoate **1b**. The general procedure yielded **1b** (14.6g, quantitative) as a white crystalline solid from 12-hydroxyoctadecanoic acid (13.9g, 42.2mmol). (mp 56-58°C). $\nu_{max.}$ ($CHCl_3$) 3010 (m), 2930 (vs), 2860 (s), 1732 (vs), 1440 (m), 1230 (br, m) and 1175 (m); δ_H (200MHz) 0.88 (3H, ca. t, *J* 7.0Hz, CH_3), 1.15-1.72 (28H, m, $OCCH_2(C\underline{H}_2)_9CH(C\underline{H}_2)_5CH_3$), 2.31 (2H, t, *J* 7.0Hz, CH_2CO), 3.58 (1H, m, $C\underline{H}OH$), 3.67 (3H, s, OCH_3); δ_C (50.4MHz, DEPT) 174.60 (C=O), 77.92 (CHOH), 37.34, 33.95, 31.70, 29.23, 28.97, 25.46, 24.75, 22.45 (CH_2), 51.31 (OCH_3) and 13.88 (CH_3); *m/z* (C.I., NH_3) 314 (M^+, 17%), 298 (25), 292 (100), 283 (10), 267 (35), 249 (10), 229 (8), 214 (20), 200 (10), 95 (10), 81 (8), 69 (5).

12-Oxamethyldodecanoate **8**. To a sirred solution of oxalyl chloride (1.75ml, 20mmol) in dry dichloromethane (50ml) at -60°C under argon was added slowly, over 5min, a solution of dimethylsulphoxide (2.8ml, 40mmol) in dichloromethane (10ml). The mixture was stirred for 10min, then methyl 12-hydroxydodecanoate **1d** (4.2g, 18.2mmol) dissolved in dichloromethane (20ml) was added dropwise, over 10min, and stirred for a further 45min. Triethylamine (12.7ml, 91mmol) was carefully added and the white precipitate allowed to warm up to room temperature and stirred for 10min. Water (50ml) was added, the layers separated and the aqueous phase extracted with dichloromethane (3x100ml). The combined organic portions were washed with brine then dried ($MgSO_4$), filtered and concentrated to yield **8** (3.6g, 87%) as a colourless oil after column chromatography (SiO_2; 10%, ether/petrol). $\nu_{max.}$ (thin film) 2960 (s), 2920 (vs), 2858 (s), 2720 (w), 1735 (vs), 1465 (m), 1435 (m), 1365 (m), 1250 (m), 1198 (m), 1160 (s), 1108 (m), 1015 (w) and 720 (w); δ_H (200MHz) 1.23 (12H, br, s, $CO_2C_2H_4(C\underline{H}_2)_6$), 1.45-1.68 (4H, m, $CO_2CH_2C\underline{H}_2$ and $C\underline{H}_2CH_2CO$), 2.25 (2H, t, *J* 7.0Hz, CO_2CH_2), 2.33 (2H, dt, *J* 1.5, 7.5Hz, CH_2CO), 3.61 (3H, s, OCH_3), 9.71 (1H, t, *J* 1.5Hz, CHO); δ_C (50.4MHz, DEPT) 174.45 (C=O), 48.72, 33.85, 29.11, 28.90, 24.69, 21.81 (CH_2), 51.26 (OCH_3); *m/z* (C.I., NH_3) 247 (8%), 246 (MNH_4^+, 52%), 230 (20), 229 (MH^+, 100), 214 (30), 197 (20), 185 (14), 153 (10), 135 (4), 112 (5), 98 (6), 95 (6), 81 (6), 74 (8) and 55 (7).

Methyl 12-hydroxytridecanoate **1c**. To a solution of the aldehyde **8** (3.24g, 14.3mmol) in dry THF (50ml) at -78°C under argon was added dropwise, over 5min, methylmagnesium bromide (10.43ml of a 1.5M solution in THF). The cloudy mixture formed was stirred at -78°C for 2h and then quenched with saturated aqueous ammonium chloride solution. The biphasic mixture was extracted with ethyl acetate and the combined organic extracts were dried ($MgSO_4$), filtered and concentrated under reduced pressure. The resulting residue was purified by flash column chromatography (SiO_2; 20%, ether/petrol) to afford **1c** (2.8g, 81%) as a white crystalline solid (m.p. 36-38°C). $\nu_{max.}$ (thin film) 3700-3100 (br, s), 2970 (m), 2920 (vs), 2850 (s), 1732 (vs), 1465 (m), 1370 (m), 1210 (m), 1130 (s), 1030 (m) 1000 (m) and 730 (m); δ_H (200MHz) 1.14 (3H, d, *J* 6.5Hz, CH_3), 1.15-1.45 (16H, br, s, $CO_2C_2H_4(C\underline{H}_2)_8$), 1.45-1.65 (2H, m, $CO_2CH_2C\underline{H}_2$), 2.26 (2H, t, *J* 7.0Hz, CO_2CH_2), 3.62 (3H, s, OCH_3), 3.72 (1H, m, C<u>H</u>OH); δ_C (50.4MHz, DEPT) 174.60 (C=O), 67.93 (CHOH), 39.17, 33.91, 29.30, 29.21, 29.03, 28.93, 25.50, 24.72 (CH_2), 51.32 (OCH_3) and 23.30 (CH_3); *m/z* (C.I., NH_3) 264 (3%), 262 (MNH_4^+, 15%), 245 (MH^+, 35), 227 (100), 214 (4), 200 (7), 195 (8), 177 (4), 152 (4), 95 (3), 87 (2) and 55 (4).

Methyl 12-hydroxydodecanoate **1d**. The general procedure yielded **1d** (10.2g, 96%) as a white crystalline solid from 12-hydroxydodecanoic acid (10.0g, 26mmol). (mp 34-36°C). $\nu_{max.}$ ($CHCl_3$) 3650-3200 (br), 2942 (vs), 2850 (vs), 1725 (s), 1460 (m), 1438 (s), 1230 (br, m), 1100 (m) and 1000 (br, m); δ_H (200MHz) 1.26 (14H, br, s, $HOC_2H_4(C\underline{H}_2)_7$), 1.42-1.63 (4H, m, $OCH_2C\underline{H}_2(CH_2)_7C\underline{H}_2$), 2.29 (2H, t, *J* 8.0Hz, CH_2CO), 3.62 (2H, t, *J* 7.0Hz, $C\underline{H}_2OH$), 3.65 (3H, s, OCH_3); δ_C (50.4MHz, DEPT) 174.60 (C=O), 62.90 (CH_2OH), 33.96, 32.60, 29.23, 29.05, 28.95, 25.56, 24.75 (CH_2), 51.36 (CH_3); *m/z* (C.I., NH_3) 248 (MNH_4^+, 14%), 232 (15), 231 (MH^+, 100), 213 (7), 199 (20), 181 (8), 168 (5), 110 (4), 90 (11), 87 (5), 74 (4), 69 (5), 55 (9).

Methyl 10-hydroxydecanoate **1e**. The general procedure yielded **1e** (1.05g, quantitative) as a colourless oil from 10-hydroxydecanoic acid (1.0g, 5.3mmol). $\nu_{max.}$ (thin film) 3660-3100 (br, s), 2930 (vs), 2860 (s), 1740 (br, vs), 1440 (s), 1200 (s), 1175 (s), 1160 (m) and 725 (m); δ_H (200MHz) 1.25 (10H, br, s, $HOC_2H_4(C\underline{H}_2)_5$), 1.50-1.65 (4H, m, $OCH_2C\underline{H}_2(CH_2)_5C\underline{H}_2$), 2.26 (2H, t, *J* 7.0Hz, CH_2CO), 3.58 (2H, t, *J* 7.0Hz, $C\underline{H}_2OH$), 3.62 (3H, s, OCH_3); δ_C (50.4MHz, DEPT) 174.72 (C=O), 62.76 (CH_2OH), 33.93, 32.55, 29.21, 28.94, 25.56, 24.75 (CH_2), 51.40 (CH_3); *m/z* (C.I., NH_3) 248 (5%), 231 (10), 220 (MNH_4^+, 35), 203 (MH^+, 100), 185 (13), 171 (8), 153 (12), 135 (5), 110 (5), 98 (10), 74 (10), 69 (7), 59 (5) and 55 (12).

Oxacyclononan-2-one **6**. Cyclooctanone (2.5g, 20mmol) and m-chloroperbenzoic acid (1.25 equiv.) dissolved in dichloromethane (20ml) was stirred for 14h at room temperature. The resulting cloudy mixture was then washed with saturated sodium bicarbonate and brine. The organic layer was dried ($MgSO_4$) and concentrated *in vacuo*. Kugelrohr distillation (80°C, 0.1mmHg) afforded the desired lactone **6** (1.4g, 49%) as a colourless oil. $\nu_{max.}$ (thin film) 2930 (vs), 2860 (m), 1732 (vs), 1458 (m), 1350 (m), 1270 (s), 1238 (s), 1142 (s), 1030 (s) and 972 (m); δ_H (200MHz) 1.20-1.80 (10H, br, m, C4-C8-$(H_2)_5$), 2.26 (2H, t, *J* 6.0Hz, C3-H_2), 4.25 (2H, t, *J* 5.5Hz, C9-H_2); δ_C (50.4MHz, DEPT) 175.84 (C=O), 64.28 (OCH_2), 35.34, 29.22, 27.48, 24.82, 23.82, 22.64 (CH_2); *m/z* (C.I., NH_3) 161 (10%), 160 (MNH_4^+, 100), 144 (10), 143 (MH^+, 98), 125 (20), 124 (14), 112 (10), 96 (12), 82 (8), 68 (12), 58 (8) and 55 (5)

Oxacyclooctan-2-one **7**. The above procedure with cycloheptanone (2.1ml, 20mmol) gave after Kugelrohr distillation (70°C, 0.1mmHg) the required lactone lactone **7** (1.2g, 47%) as a colourless oil [87% based on recovered starting material (50°C, 0.1mmHg)]. $\nu_{max.}$ (thin film) 2922 (s), 2860 (m), 1729 (vs), 1450 (m), 1352 (m), 1298 (m), 1232 (s), 1130 (s), 1008 (m), 998 (m) and 730 (s); δ_H (200MHz) 1.38-1.82 (8H, br, m, C4-C7-$(H_2)_4$), 2.45 (2H, t, *J* 6.0Hz, C3-H_2), 4.25 (2H, t, *J* 5.5Hz, C8-H_2); δ_C (50.4MHz, DEPT) 176.93 (C=O), 67.78 (OCH_2), 31.01, 30.51, 28.09, 25.44, 23.56 (CH_2); *m/z* (C.I., NH_3) 147 (8%), 146 (MNH_4^+, 100), 130 (8), 129 (MH^+, 86), 85 (16), 83 (30), 64 (12) and 55 (5)

General procedure for the preparation of methyl ω-hydroxyalkanoates **1f-1h.** To a stirred solution of the appropiate lactone in methanol (ca. 10ml/mmol) under argon at room temperature was added boron trifluoride etherate (0.075 equiv.) and the resulting mixture was stirred overnight. The methanol was then removed *in vacuo* to ca. 20ml and the mixture added to water (50ml). The aqueous was throughly extracted with ether then washed with brine, dried ($MgSO_4$), filtered and concentrated to afford the methyl ω-hydroxyalkanoates as colourless oils which were purified as detailed below.

Methyl 8-hydroxyoctanoate **1f**. The general procedure using BF_3 etherate in methanol on the lactone **6** (1.05g, 7.4mmol) afforded the title compound (1.17g, 91%) as a colourless oil after column chromatography (SiO_2; 20% ether/petrol). $\nu_{max.}$ (thin film) 3700-3100 (br, s), 2922 (s), 2850 (m), 1735 (s), 1435 (m), 1200 (m), 1173 (m) and 1068 (m); δ_H (200MHz) 1.23 (6H, br s, $HOC_2H_4(C\underline{H}_2)_3$), 1.36-1.63 (4H, m, $HOCH_2$-$C\underline{H}_2(CH_2)_3C\underline{H}_2$), 2.21 (2H, t, *J* 7.0Hz, CH_2CO), 3.50 (2H, t, *J* 8.0Hz, $C\underline{H}_2OH$), 3.56 (3H, s, OCH_3); δ_C (50.4MHz, DEPT) 174.67 (C=O), 62.36 (CH_2OH), 33.79, 32.32, 28.79, 25.30, 24.57 (CH_2), 51.32 (CH_3); *m/z* (C.I., NH_3) 192 (MNH_4^+, 65%), 176 (10), 175 (MH^+, 100), 157 (6), 143 (8), 125 (5), 96 (5) and 55 (5).

Methyl 7-hydroxyheptanoate **1g**. The general procedure using BF_3 etherate in methanol on the lactone **7** (952mg, 7.44mmol) afforded the title compound (1.03g, 87%) as a colourless oil after Kugelrohr distillation (120°C, 0.2mmHg). $\nu_{max.}$ (thin film) 3700-3100 (br, s), 2930 (vs), 2858 (s), 1735 (br, vs), 1460 (m), 1435 (s), 1368 (m), 1255 (m), 1200 (s), 1175 (s) and 1052 (m); δ_H (200MHz) 1.08-1.29 (4H, m, $HOC_2H_4C_2\underline{H}_4$), 1.29-1.54 (4H, m, $OCH_2C\underline{H}_2C_2H_4C\underline{H}_2$), 2.14 (2H, t, *J* 7.0Hz, CH_2CO), 3.41 (2H, t, *J* 8.0Hz, $C\underline{H}_2OH$), 3.67 (3H, s, OCH_3); δ_C (50.4MHz, DEPT) 174.59 (C=O), 62.06 (CH_2OH), 33.67, 32.11, 28.62, 25.15, 24.56 (CH_2), 51.25 (CH_3); *m/z* (C.I., NH_3) 178 (MNH_4^+, 66%), 162 (10), 161 (MH^+, 100), 146 (8), 129 (20), 111 (3), 82 (3), 58 (2) and 55 (3).

Methyl 6-hydroxyhexanoate **1h**. The general procedure using BF_3 etherate in methanol gave the title compound (2.21g, 76%) as a colourless oil from ε-caprolactone (2.2ml, 20mmol) after purification by Kugelrohr distillation (105°C, 0.2mmHg). $\nu_{max.}$ (thin film) 3700-3080 (br, s), 2940 (vs), 2864 (s), 1740 (br, vs), 1440 (s), 1368 (m), 1245-1155 (br, s) 1055 (m) and 1025 (m); δ_H (200MHz) 1.32-1.48 (2H, m, $HOC_2H_4C\underline{H}_2$), 1.48-1.74 (4H, m, $OCH_2C\underline{H}_2CH_2C\underline{H}_2$), 2.33 (2H, t, *J* 7.0Hz, CH_2CO), 3.65 (2H, t, *J* 7.0Hz, $C\underline{H}_2OH$), 3.67 (3H, s, OCH_3); δ_C (50.4MHz, DEPT) 174.68 (C=O), 62.06 (CH_2OH), 33.78, 31.99, 25.09, 24.43 (CH_2), 51.40 (CH_3); *m/z* (C.I., NH_3) 164 (MNH_4^+, 3%), 148 (8), 147 (MH^+, 100), 139 (37), 115 (73), 97 (30), 87 (33), 74 (36), 69 (37), 68 (21), 59 (16) and 55 (38).

General procedure for the preparation of methyl (ω-propiolate)-alkanoates **2a-2h**. A mixture of the desired alcohol (1.0 equiv.) and triphenylphosphine (2.0 equiv.) in dry THF (=5ml/mmol) was added dropwise, over 0.5h, to a stirred solution of propiolic acid (2.0 equiv.) and DEAD (2.0 equiv.) in same amount of solvent under argon at room temperature. The reaction mixture was stirred overnight and then concentrated under reduced pressure. The reddish brown residue obtained was purified by flash column chromatography (SiO_2; 10%, ether/petrol) to afford the desired propiolate ester **2a-2h**.

Methyl (16-propiolate)-hexadecanoate **2a**. Obtained as a white crystalline solid (1.13g, 96%) from methyl 16-hydroxyhexadecanoate **1a** (1.0g, 3.5mmol). (Found: C, 71.14; H, 10.37. $C_{20}H_{34}O_4$ requires C, 70.97; H, 10.12%); (m.p. 48-50°C); $\nu_{max.}$ ($CHCl_3$) 3250 (w), 3045 (m), 2932 (vs), 2860 (s), 2120 (s), 1715 (br, vs), 1440 (m), 1250-1210 (br, vs) and 662 (s); δ_H (200MHz) 1.21 (22H, br, s, $OC_2H_4(C\underline{H}_2)_{11}$), 1.50-1.73 (4H, m, $OCH_2C\underline{H}_2(CH_2)_{11}C\underline{H}_2$), 2.29 (2H, t, *J* 8.0Hz, CH_2CO), 2.89 (1H, s, CCH), 3.65 (3H, s, OCH_3), 4.18 (2H, t, *J* 7.0Hz, OCH_2); δ_C (50.4MHz, DEPT) 174.56 ($\underline{C}O_2CH_3$), 153.02 ($\underline{C}$=O), 74.40 ($C\underline{C}H$), 63.43 (OCH_2), 33.96, 29.45, 29.28, 29.00, 28.14, 25.56, 24.78 (CH_2), 51.32 (OCH_3); *m/z* (C.I., NH_3) 357 (12%), 356 (MNH_4^+, 100), 339 (MH^+, 75), 324 (18), 307 (10), 286 (32), 269 (15), 83 (9), 70 (8) and 58 (8).

Methyl (12-propiolate)-octadecanoate **2b**. Obtained as a colourless oil (3.9g, 82%) from methyl 12-hydroxyoctadecanoate **1b** (4.08g, 13.0mmol). (Found: C, 71.94; H, 10.80. $C_{22}H_{38}O_4$ requires C, 72.09; H, 10.45%); $\nu_{max.}$ (thin film) 3250 (w), 2922 (vs), 2858 (s), 2120 (m), 1740 (s), 1712 (vs), 1460 (m), 1435 (m), 1235 (br, vs) and 752 (m); δ_H (200MHz) 0.87 (3H, ca. t, *J* 7.0Hz, CH_3), 1.26 (22H, br, s, $OCC_2H_4(C\underline{H}_2)_7$ and $(C\underline{H}_2)_4CH_3$), 1.42-1.78 (6H, m, $OCCH_2C\underline{H}_2$ and $C\underline{H}_2CHC\underline{H}_2$), 2.30 (2H, t, *J* 8.0Hz, CH_2CO), 2.89 (1H, s, CCH), 3.66 (3H, s, OCH_3), 4.97 (1H, quin., *J* 5.0Hz, OCH); δ_C (50.4MHz, DEPT) 174.57 ($\underline{C}O_2CH_3$), 153.84 (C=O), 77.28 (OCH), 74.18 ($C\underline{C}H$), 33.94, 33.73, 31.57, 29.23, 29.05, 28.95, 25.01, 24.76, 22.38 (CH_2), 51.32 (OCH_3) and 13.84 (CH_3); *m/z* (C.I., NH_3) 384 (MNH_4^+, 10%), 315 (20), 314 (100), 297 (32), 295 (5), 264 (4), 114 (4), 100 (5), 83 (4) and 58 (6).

Methyl (12-propiolate)-tridecanoate **2c**. Obtained as a colourless oil (2.53g, 80%) from methyl 12-hydroxytridecanoate **1c** (2.6g, 10.7mmol). (Found: C, 69.17; H, 9.90. $C_{17}H_{28}O_4$ requires C, 68.89; H, 9.52%); $\nu_{max.}$ (thin film) 3250 (m), 2982 (m), 2930 (vs), 2860 (s), 2120 (s), 1740 (vs), 1712 (vs), 1440 (m), 1465 (m), 1435 (m), 1240 (br, vs), 1172 (m) and 760 (s); δ_H (200MHz) 1.18-1.35 (17H, br, s, $OCC_2H_4(C\underline{H}_2)_7$ and $CHC\underline{H}_3$), 1.45-1.68 (4H, m, $OCCH_2C\underline{H}_2(CH_2)_7C\underline{H}_2$), 2.28 (2H, t, *J* 8.0Hz, CH_2CO), 2.88 (1H, s, CCH), 3.64 (3H, s, OCH_3), 4.98 (1H, m, OCH); δ_C (50.4MHz, DEPT) 174.52 ($\underline{C}O_2CH_3$), 153.58 (C=O), 75.05 ($\underline{C}CH$), 74.11 ($C\underline{C}H$), 73.79 (OCH), 35.46, 33.91, 29.51, 29.22, 29.04, 28.94, 25.07, 24.75 (CH_2), 51.30 (OCH_3) and 19.52 (CH_3); *m/z* (C.I., NH_3) 315 (5%), 314 (MNH_4^+, 25), 297 (MH^+, 45), 244 (6), 228 (17), 227 (100), 195 (17), 194 (12), 177 (6), 152 (8), 110 (8), 96 (8), 81 (6), 68 (6) and 53 (17).

Methyl (12-propiolate)-dodecanoate **2d**. Obtained as a colourless oil (2.7g, 96%) from methyl 12-hydroxydodecanoate **1d** (2.3g, 10mmol). (Found: C, 68.01; H, 9.67. $C_{16}H_{26}O_4$ requires C, 68.06; H, 9.28%); $\nu_{max.}$ ($CHCl_3$) 3300 (m), 2932 (vs), 2860 (s), 2120 (s), 1735-1710 (vs), 1465 (m), 1435 (m), 1240 (br, s), 1180 (m) and 835 (w); δ_H (200MHz) 1.24 (14H, br, s, $OC_2H_4(C\underline{H}_2)_7$), 1.48-1.74 (4H, m, $OCCH_2C\underline{H}_2(CH_2)_7C\underline{H}_2$), 2.27 (2H, t, *J* 8.0Hz, CH_2CO), 2.88 (1H, s, CCH), 3.63 (3H, s, OCH_3), 4.16 (2H,

t, *J* 7.0Hz, OCH_2); δ_C (50.4MHz, DEPT) 174.57 ($\underline{C}O_2CH_3$), 153.57 (C=O), 74.40 ($C\underline{C}H$), 66.41 (OCH_2) 33.93, 29.22, 29.04, 28.94, 28.11, 25.55, 24.75 (CH_2), 51.33 (OCH_3); *m/z* (C.I., NH_3) 311 (5%), 300 (MNH_4^+, 100), 283 (MH^+, 58), 258 (8), 232 (10), 237 (5), 195 (15), 98 (5), 82 (6) and 55 (15).

Methyl (10-propiolate)-decanoate **2e**. Obtained as a colourless oil (1.12g, 88%) from methyl 10-hydroxydecanoate **1e** (1.0g, 5.0mmol). $\nu_{max.}$ ($CHCl_3$) 3300 (m), 3045 (m), 2932 (vs), 2860 (s), 2120 (s), 1715 (br, vs), 1440 (m), 1250-1210 (br, vs) and 662 (s); δ_H (200MHz) 1.29 (10H, s, $OC_2H_4(C\underline{H}_2)_5$), 1.50-1.80 (4H, m, $OCH_2C\underline{H}_2(CH_2)_5C\underline{H}_2$), 2.30 (2H, t, *J* 7.5Hz, CH_2CO), 2.91 (1H, s, CCH), 3.66 (3H, s, OCH_3), 4.18 (2H, t, *J* 7.0Hz, OCH_2); δ_C (50.4MHz, DEPT) 174.61 ($\underline{C}O_2CH_3$), 153.00 (C=O), 74.77 ($\underline{C}CH$), 74.52 ($C\underline{C}H$), 66.42 (OCH_2), 33.94, 29.09, 28.94, 28.14, 25.56, 24.76 (CH_2), 51.40 (OCH_3); *m/z* (C.I., NH_3) 274 (20%), 272 (MNH_4^+, 100), 259 (10), 257 (32), 255 (MH^+, 65), 240 (15), 202 (16), 185 (12), 152 (5), 98 (5), 72 (7) and 55 (9).

Methyl (8-propiolate)-octanoate **2f**. Obtained as a colourless oil (1.37g, 90%) from methyl 8-hydroxyoctanoate **1f** (1.18g, 6.75mmol). (Found: C, 64.01; H, 8.33. $C_{12}H_{18}O_4$ requires C, 63.70; H, 8.02%); $\nu_{max.}$ (thin film) 3250 (m), 2930 (m), 2858 (m), 2120 (m), 1740-1710 (br, s), 1460 (m), 1435 (m), 1230 (br, vs) and 758 (m); δ_H (200MHz) 1.15-1.50 (6H, s, $OC_2H_4(C\underline{H}_2)_3$), 1.50-1.70 (4H, m, $OCH_2C\underline{H}_2(CH_2)_3C\underline{H}_2$), 2.24 (2H, t, *J* 7.5Hz, CH_2CO), 2.93 (1H, s, CCH), 3.60 (3H, s, OCH_3), 4.11 (2H, t, *J* 7.0Hz, OCH_2); δ_C (50.4MHz, DEPT) 174.56 ($\underline{C}O_2CH_3$), 152.94 (C=O), 75.23 ($\underline{C}CH$), 74.73 ($C\underline{C}H$), 66.21 (OCH_2), 33.75, 28.68, 28.54, 27.99, 25.33, 24.54 (CH_2), 51.36 (OCH_3); *m/z* (C.I., NH_3) 246 (38%), 244 (MNH_4^+, 95), 231 (23), 229 (80), 227 (MH^+, 100), 212 (12), 195 (10), 153 (13), 124 (13), 96 (12), 82 (5) and 55 (25).

Methyl (7-propiolate)-heptanoate **2g**. Obtained as a colourless oil (940mg, 86%) from methyl 7-hydroxyheptanoate **1g** (828mg, 5.18mmol). (Found: C, 62.32; H, 7.61. $C_{11}H_{16}O_4$ requires C, 62.25; H, 7.60%); $\nu_{max.}$ (thin film) 3250 (m), 2940 (m), 2860 (m), 2120 (s), 1735 (vs), 1712 (vs), 1460 (m), 1435 (m), 1230 (br, vs) and 758 (m); δ_H (200MHz) 1.22-1.74 (8H, m, $OCH_2(C\underline{H}_2)_4$), 2.30 (2H, t, *J* 7.5Hz, CH_2CO), 2.90 (1H, s, CCH), 3.65 (3H, s, OCH_3), 4.17 (2H, t, *J* 7.0Hz, OCH_2); δ_C (50.4MHz, DEPT) 174.30 ($\underline{C}O_2CH_3$), 152.96 (C=O), 74.58 ($C\underline{C}H$), 66.17 (OCH_2), 33.74, 28.46, 27.94, 25.26, 24.53 (CH_2), 51.39 (OCH_3); *m/z* (C.I., NH_3) 231 (12%), 230 (MNH_4^+, 90), 214 (12), 213 (MH^+, 100), 198 (15), 143 (15), 128 (12), 110 (12), 82 (8), 69 (10) and 55 (15).

Methyl (6-propiolate)-hexanoate **2h**. Obtained as a colourless oil (2.5g, 97%) from methyl 6-hydroxyhexanoate **1h** (1.9g, 13mmol). (Found: C, 61.01; H, 6.97. $C_{10}H_{14}O_4$ requires C, 60.59; H, 7.12%); $\nu_{max.}$ (thin film) 3258 (s), 2958 (s), 2870 (m), 2120 (s), 1735-1712 (vs), 1460 (m), 1440 (s), 1230 (br, vs), 1170 (s), 1105 (w) and 758 (m); δ_H (200MHz) 1.27-1.42 (2H, m, $OC_2H_4C\underline{H}_2$), 1.50-1.71 (4H, m, $OCH_2C\underline{H}_2CH_2C\underline{H}_2$), 2.25 (2H, t, *J* 7.5Hz, CH_2CO), 2.94 (1H, s, CCH), 3.58 (3H, s, OCH_3), 4.11 (2H, t, *J* 7.0Hz, OCH_2); δ_C (50.4MHz, DEPT) 174.00 ($\underline{C}O_2CH_3$), 152.83 (C=O), 74.80 ($C\underline{C}H$), 74.58 ($C\underline{C}H$), 65.88 (OCH_2), 33.53, 27.76, 25.07, 24.17 (CH_2), 51.32 (OCH_3); *m/z* (C.I., NH_3) 218 (10%), 216 (MNH_4^+, 86), 199 (MH^+, 60), 167 (16), 129 (100), 114 (10), 100 (6), 97 (23), 87 (12), 74 (8), 68 (23), 59 (6) and 55 (23).

General procedure for the preparation of methyl ω-(3-tributylstannyl propenoate)-alkenoates **3a-3h**. To a stirred solution of the appropriate propiolate esters **2a-2h** (1.0 equiv.) and tributyltin hydride (1.2 equiv.) in sodium dried benzene (10ml/mmol) was added triethylborane (0.1 equiv. of a 1M solution in hexanes) under argon at room temperature. The reaction mixture was stirred 0.5-1h until the reaction was completed by t.l.c. analysis and then concentrated *in vacuo*. The residue obtained was purified by flash column chromatography (SiO_2; 5%, ether/petrol) to afford almost quantitatively* the β-stannylalkenoate as colourless oils in roughly 1:1 mixture of *E*- and *Z*- isomers. Data given below only for the specific isomer used in subsequent reactions.

Methyl 16-(3-tributylstannyl propenoate)-hexadecanoate **3a**. Obtained as a colourless oil from **2a** (1.0g, 2.95mmol). Data for *E*- **3a**; $\nu_{max.}$ (thin film) 2958 (s), 2922 (vs), 2858 (s), 1745 (s), 1729 (s), 1592 (w), 1465 (m), 1438 (m), 1255 (m), 1205 (s), 1158 (s), 998 (m) and 735 (w); δ_H (200MHz) 0.82-1.02 (15H, m, ($CH_3C_2H_4CH_2)_3Sn$-), 1.20-1.72 (38H, m, $OCH_2(CH_2)_{13}$ and ($CH_3C_2H_4CH_2)_3Sn$-), 2.30 (2H, t, *J* 7.5Hz, CH_2CO), 3.66 (3H, s, OCH_3), 4.13 (2H, t, *J* 7.0Hz, OCH_2), 6.30 (1H, d, *J* 20.0Hz, CH=CHSn), 7.72 (1H, d, *J* 20.0Hz, CH=CHSn); δ_C (50.4MHz, DEPT) 174.57 (CO_2CH_3), 165.21 (C=O), 152.47 (CH=CHSn), 136.52 (CH=CHSn), 64.54 (OCH_2), 33.96, 29.48, 29.30, 29.12, 29.00, 28.53, 25.81, 24.79 (CH_2), 28.80, 27.08 ($SnCH_2CH_2$), 9.40 ($SnCH_2$), 51.33 (OCH_3) and 13.44 (CH_3); *m/z* (C.I., NH_3) 631 (MH^+, Sn^{120}, 10%), 573 (M^+-Bu, 100), 571 (80), 569 (40), 305 (50), 291 (22), 191 (20), 138 (18), 74 (30) and 55 (50).

Methyl 12-(3-tributylstannyl propenoate)-octadecanoate **3b**. Obtained as a colourless oil from **2b** (3.0g, 8.2mmol). Data for *Z*- **3b**; (Found: C, 61.94; H, 10.15. $C_{34}H_{66}O_4Sn$ requires C, 62.10; H, 10.12%); $\nu_{max.}$ (thin film) 2958 (s), 2922 (vs), 2858 (s), 1742 (s), 1708 (s), 1590 (w), 1465 (m), 1438 (m), 1335 (m), 1205 (s), 1175 (m), 910 (w), 825 (m) and 740 (s); δ_H (200MHz) 0.78-1.04 (18H, m, ($CH_3C_2H_4CH_2)_3Sn$- and CH_3), 1.04-1.74 (40H, m, $(CH_2)_5OCH(CH_2)_9$ and ($CH_3C_2H_4CH_2)_3Sn$-), 2.29 (2H, t, *J* 7.5Hz, CH_2CO), 3.66 (3H, s, OCH_3), 4.96 (1H, m, OCH), 6.72 (1H, d, *J* 13.0Hz, CH=CHSn), 7.14 (1H, d, *J* 13.0Hz, CH=CHSn); δ_C (50.4MHz, DEPT) 174.58 (CO_2CH_3), 167.95 (C=O), 157.17 (CH=CHSn), 135.70 (CH=CHSn), 74.24 (OCH), 34.20, 33.97, 31.82, 31.64, 29.56, 29.41, 29.05, 27.48, 25.15, 24.81, 22.46 (CH_2), 28.86, 27.22 ($SnCH_2CH_2$), 10.89 ($SnCH_2$), 51.33 (OCH_3), 13.90 (CH_3) and 13.58 ($Sn(CH_2)_3CH_3$); *m/z* (C.I., NH_3) 601 (M^+-Bu, Sn^{120}, 100%), 599 (70), 597 (41), 305 (70), 303 (57), 301 (32), 249 (15), 191 (25), 177 (21), 97 (22), 87 (18), 83 (18), 74 (34), 69 (26) and 55 (65).

Methyl 12-(3-tributylstannyl propenoate)-tridecanoate **3c**. Obtained as a colourless oil from **2c** (3.0g, 8.2mmol). Data for *E*- **3c**; (Found: C, 59.00; H, 9.83. $C_{29}H_{56}O_4Sn$ requires C, 59.29; H, 9.61%); $\nu_{max.}$ (thin film) 2958 (s), 2922 (vs), 2858 (s), 1740 (s), 1720 (s), 1590 (w), 1465 (m), 1438 (m), 1262 (m), 1205 (vs), 1160 (m), 998 (m) and 742 (w); δ_H (200MHz) 0.82-1.02 (15H, m, ($CH_3C_2H_4CH_2)_3Sn$-), 1.18-1.72 (33H, m, $(CH_2)_9O$-$CHCH_3$ and ($CH_3C_2H_4CH_2)_3Sn$-), 2.30 (2H, t, *J* 7.5Hz, CH_2CO), 3.67 (3H, s, OCH_3), 4.97 (1H, m, OCH), 6.28 (1H, d, *J* 20.0Hz, CH=CHSn), 7.72 (1H, d, *J* 20.0Hz, CH=CHSn); δ_C (50.4MHz, DEPT) 174.56 (CO_2CH_3), 165.02 (C=O), 152.03 (CH=CHSn), 136.91 (CH=CHSn), 74.43 (OCH), 34.06, 33.96, 31.59, 29.35, 29.27, 29.08, 25.13, 24.79, 22.42 (CH_2), 28.81, 27.08 ($SnCH_2CH_2$), 9.39 ($SnCH_2$), 51.32

* Determined on the basis of ^1H n.m.r. analysis of the crude reaction mixture.

(OCH_3), 13.87 (CH_3) and 13.45 ($Sn(CH_2)_3\underline{C}H_3$); *m/z* (C.I., NH_3) 589 (MH^+, Sn^{120}, 22%), 531 (M^+-Bu, Sn^{120}, 100), 529 (80), 527 (42), 345 (8), 305 (55), 303 (43), 227 (30), 191 (12), 138 (11), 121 (5), 95 (5), 74 (7), 69 (6) and 55 (65).

Methyl 12-(3-tributylstannyl propenoate)-dodecanoate **3d**. Obtained as a colourless oil from **2d** (1.5g, 5.3mmol). Data for *E*- **3d**, (Found: C, 58.69; H, 9.82. $C_{28}H_{54}O_4Sn$ requires C, 58.55; H, 9.65%); $\nu_{max.}$ (thin film) 2960 (s), 2925 (vs), 2860 (s), 1742 (s), 1726 (s), 1590 (w), 1465 (m), 1438 (m), 1255 (m), 1205 (s), 1158 (m) and 998 (w); δ_H (200MHz) 0.78-1.02 (15H, m, ($C\underline{H}_3C_2H_4C\underline{H}_2)_3Sn$-), 1.18-1.74 (30H, m, $OCH_2(C\underline{H}_2)_9$ and ($CH_3C_2\underline{H}_4$-$CH_2)_3Sn$-), 2.28 (2H, t, *J* 7.5Hz, CH_2CO), 3.63 (3H, s, OCH_3), 4.10 (2H, t, *J* 7.0Hz, OCH_2), 6.26 (1H, d, *J* 20.0Hz, $C\underline{H}$=CHSn), 7.70 (1H, d, *J* 20.0Hz, CH=$C\underline{H}$Sn); δ_C (50.4MHz, DEPT) 174.49 ($\underline{C}O_2CH_3$), 165.17 (C=O), 152.44 (CH=$\underline{C}$HSn), 136.51 ($\underline{C}$H=CHSn), 64.50 (OCH_2), 33.91, 29.30, 29.07, 28.86, 28.50, 27.38, 25.77, 24.74 (CH_2), 28.77, 27.04 ($SnCH_2\underline{C}_2H_4$), 9.38 ($SnCH_2$), 51.29 (OCH_3), and 13.41 (CH_3); *m/z* (C.I., NH_3) 575 (MH^+, Sn^{120}, 23%), 573 (20), 517 (M^+-Bu, Sn^{120}, 100), 515 (72), 513 (42), 403 (8), 305 (23), 285 (32), 270 (10), 231 (10), 138 (10), 121 (5), 95 (4), 74 (4), 69 (4) and 55 (17).

Methyl 10-(3-tributylstannyl propenoate)-decanoate **3e**. Obtained as a colourless oil from **2e** (991mg, 3.9mmol). Data for *E*- **3e**; $\nu_{max.}$ (thin film) 2960 (s), 2930 (vs), 2860 (s), 1742 (s), 1728 (s), 1590 (w), 1468 (m), 1438 (m), 1255 (m), 1208 (s), 1158 (m) and 998 (w); δ_H (200MHz) 0.78-1.02 (15H, m, ($C\underline{H}_3C_2H_4C\underline{H}_2)_3Sn$-), 1.20-1.72 (26H, m, $OCH_2(C\underline{H}_2)_7$ and ($CH_3C_2\underline{H}_4CH_2)_3Sn$-), 2.28 (2H, t, *J* 7.5Hz, CH_2CO), 3.64 (3H, s, OCH_3), 4.12 (2H, t, *J* 7.0Hz, OCH_2), 6.28 (1H, d, *J* 20.0Hz, $C\underline{H}$=CHSn), 7.72 (1H, d, *J* 20.0Hz, CH=$C\underline{H}$Sn); δ_C (50.4MHz, DEPT) 174.46 ($\underline{C}O_2CH_3$), 165.17 (C=O), 152.47 (CH=$\underline{C}$HSn), 136.52 ($\underline{C}$H=CHSn), 64.47 (OCH_2), 33.89, 31.43, 29.02, 28.50, 27.62, 26.51, 25.75, 24.73, 22.46 (CH_2), 28.80, 27.06 ($SnCH_2\underline{C}_2H_4$), 9.39 ($SnCH_2$), 51.29 (OCH_3), and 13.43 (CH_3); *m/z* (C.I., NH_3) 547 (MH^+, Sn^{120}, 12%), 489 (M^+-Bu, Sn^{120}, 100), 487 (88), 485 (50), 375 (8), 305 (18), 291 (12), 135 (6), 95 (4), 74 (7), 69 (5) and 55 (23).

Methyl 8-(3-tributylstannyl propenoate)-octanoate **3f**. Obtained as a colourless oil from **2f** (991mg, 3.9mmol). Data for *E*- **3f**; (Found: C, 55.74; H, 9.23. $C_{24}H_{46}O_4Sn$ requires C, 55.72; H, 8.96%); $\nu_{max.}$ (thin film) 2950 (s), 2922 (s), 2863 (m), 2850 (s), 1740 (s), 1720 (s), 1588 (w), 1462 (m), 1440 (m), 1252 (m), 1205 (s), 1155 (s), 998 (m) and 732 (w); δ_H (200MHz) 0.78-1.00 (15H, m, ($C\underline{H}_3C_2H_4C\underline{H}_2)_3Sn$-), 1.20-1.72 (22H, m, $OCH_2(C\underline{H}_2)_5$ and ($CH_3C_2\underline{H}_4CH_2)_3Sn$-), 2.27 (2H, t, *J* 7.0Hz, CH_2CO), 3.63 (3H, s, OCH_3), 4.10 (2H, t, *J* 7.0Hz, OCH_2), 6.26 (1H, d, *J* 19.5Hz, $C\underline{H}$=CHSn), 7.71 (1H, d, *J* 19.5Hz, CH=$C\underline{H}$Sn); δ_C (50.4MHz, DEPT) 174.39 ($\underline{C}O_2CH_3$), 165.14 (C=O), 152.51 (CH=$\underline{C}$HSn), 136.53 ($\underline{C}$H=CHSn), 64.39 (OCH_2), 33.84, 28.47, 25.63, 24.66 (CH_2), 28.81, 27.08 ($SnCH_2\underline{C}_2H_4$), 9.40 ($SnCH_2$), 51.30 (OCH_3), and 13.44 (CH_3); *m/z* (C.I., NH_3) 519 (MH^+, Sn^{120}, 8%), 461 (M^+-Bu, Sn^{120}, 100), 459 (73), 457 (45), 347 (8), 305 (24), 291 (9), 229 (6), 157 (4), 74 (3) and 55 (8).

Methyl 7-(3-tributylstannyl propenoate)-heptanoate **3g**. Obtained as a colourless oil from **2g** (850mg, 4.0mmol). Data for *E*- **3g**; $\nu_{max.}$ (thin film) 2958 (s), 2922 (s), 2863 (m), 2850 (s), 1740 (s), 1722 (s), 1590 (w), 1460 (m), 1445 (m), 1252 (m), 1205 (s), 1155 (s) and 998 (m); δ_H (200MHz) 0.78-1.02 (15H, m,

($CH_3C_2H_4C\underline{H}_2)_3Sn$-), 1.18-1.75 (20H, m, $OCH_2(C\underline{H}_2)_4$ and ($CH_3C_2\underline{H}_4CH_2)_3Sn$-), 2.32 (2H, t, *J* 7.5Hz, CH_2CO), 3.67 (3H, s, OCH_3), 4.14 (2H, t, *J* 6.0Hz, OCH_2), 6.30 (1H, d, *J* 19.5Hz, C<u>H</u>=CHSn), 7.75 (1H, d, *J* 19.5Hz, CH=C<u>H</u>Sn); δ_C (50.4MHz, DEPT) 174.37 ($\underline{C}O_2CH_3$), 165.15 (C=O), 152.67 (CH=<u>C</u>HSn), 136.44 (<u>C</u>H=CHSn), 64.31 (OCH_2), 33.79, 28.60, 28.34, 25.47 (CH_2), 28.79, 27.07 ($SnCH_2\underline{C}_2H_4$), 9.39 ($Sn\underline{C}H_2$), 51.36 (OCH_3), and 13.45 (CH_3); *m/z* (E.I.) 447 (M^+-Bu, Sn^{120}, 100%), 445 (75), 442 (45), 415 (10), 359 (8), 305 (20), 303 (16), 247 (10), 191 (20), 177 (23), 137 (18), 121 (14), 111 (15), 83 (17), 74 (23), 69 (21) and 55 (37).

Methyl 6-(3-tributylstannyl propenoate)-hexanoate **3h**. Obtained as a colourless oil from **2h** (2.48g, 12.5mmol). Data for <u>Z</u>- **3h**; $\nu_{max.}$ (thin film) 2958 (vs), 2920 (vs), 2878 (s), 2862 (s), 1742 (vs), 1712 (vs), 1585 (w), 1460 (m), 1440 (m), 1365 (m), 1340 (s), 1205 (s, br), 1062 (w) 826 (s) and 760 (s); δ_H (200MHz) 0.78-1.02 (15H, m, ($C\underline{H}_3C_2H_4C\underline{H}_2)_3Sn$-), 1.18-1.80 (18H, m, $OCH_2(C\underline{H}_2)_3$ and ($CH_3C_2\underline{H}_4CH_2)_3Sn$-), 2.33 (2H, t, *J* 7.5Hz, CH_2CO), 3.67 (3H, s, OCH_3), 4.15 (2H, t, *J* 7.0Hz, OCH_2), 6.73 (1H, d, *J* 13.0Hz, C<u>H</u>=CHSn), 7.17 (1H, d, *J* 13.0Hz, CH=C<u>H</u>Sn); δ_C (50.4MHz, DEPT) 174.28 ($\underline{C}O_2CH_3$), 168.08 (C=O), 157.64 (CH=<u>C</u>HSn), 135.30 (<u>C</u>H=CHSn), 64.24 (OCH_2) 33.78, 29.03, 25.37, 24.44 (CH_2), 28.26, 27.21 ($SnCH_2\underline{C}_2H_4$), 10.82 ($SnCH_2$), 51.45 (OCH_3), and 13.58 (CH_3). Data for <u>E</u>- **3h**; (Found: C, 53.38; H, 8.52. $C_{22}H_{42}O_4Sn$ requires C, 53.60; H, 8.65%); $\nu_{max.}$ (thin film) 2958 (s), 2922 (s), 2875 (m), 2865 (m), 1740 (s), 1722 (s), 1590 (w), 1460 (m), 1256 (m), 1205 (s), 1155 (s) and 998 (m); δ_H (200MHz) 0.78-1.02 (15H, m, ($C\underline{H}_3C_2H_4C\underline{H}_2)_3Sn$-), 1.18-1.80 (18H, m, $OCH_2(C\underline{H}_2)_3$ and ($CH_3C_2\underline{H}_4CH_2)_3Sn$-), 2.33 (2H, t, *J* 7.5Hz, CH_2CO), 3.67 (3H, s, OCH_3), 4.14 (2H, t, *J* 7.0Hz, OCH_2), 6.29 (1H, d, *J* 19.5Hz, C<u>H</u>=CHSn), 7.74 (1H, d, *J* 19.5Hz, CH=C<u>H</u>Sn); δ_C (50.4MHz, DEPT) 174.21 ($\underline{C}O_2CH_3$), 165.11 (C=O), 152.77 (CH=<u>C</u>HSn), 136.48 (<u>C</u>H=CHSn), 64.13 (OCH_2) 33.75, 28.24, 25.40, 24.43 (CH_2), 28.81, 27.08 ($SnCH_2\underline{C}_2H_4$), 9.40 ($SnCH_2$), 51.39 (OCH_3), and 13.44 (CH_3); *m/z* (C.I., NH_3) 491 (MH^+, Sn^{120}, 5%), 433 (M^+-Bu, Sn^{120}, 64), 431 (50), 442 (45), 429 (29), 345 (9), 305 (12), 291 (16), 233 (7), 191 (8), 129 (100), 115 (16), 97 (17), 85 (10), 69 (19), 55 (27).

General procedure for the preparation of ω-(3-tributylstannyl propenoate)-alkanoic acids **4a-4h**. Lithium hydroxide monohydrate (1.1 equiv. of a 1<u>M</u> aqueous solution) was added to a stirred solution of the appropiate methyl ester (1.0 equiv.) in (9:1) THF/water (<u>ca</u>. 10ml/mmol) at room temperature. The reaction mixture was stirred overnight and then carefully acidified to pH 4 with hydrochloric acid (2<u>M</u>). The resulting mixture was thoroughly extracted with ether, dried $MgSO_4$ and concentrated *in vacuo* to give the crude products as colourless oils which were purified by flash column chromatography (SiO_2; 20%, ether/petrol)

<u>*E*</u>*-16-(3-tributylstannyl propenoate)-hexadecanoic acid* **4a**. The general procedure afforded **4a** (328mg, 85%) as a colourless oil from **3a** (405mg, 0.64mmol). (Found: C, 61.14; H, 9.42. $C_{31}H_{60}O_4Sn$ requires C, 60.49; H, 9.83%); $\nu_{max.}$ (thin film) 3600-3000 (br, w), 2958 (s), 2920 (vs), 2850 (s), 1710 (br, s), 1590 (w), 1465 (m), 1415 (w), 1255 (m), 1205 (s), 1152 (m) and 998 (m); δ_H (200MHz) 0.82-1.02 (15H, m, ($C\underline{H}_3C_2H_4C\underline{H}_2)_3Sn$-), 1.18-1.75 (38H, m, $OCH_2(C\underline{H}_2)_{13}$ and ($CH_3C_2\underline{H}_4CH_2)_3Sn$-), 2.35 (2H, t, *J* 7.5Hz, CH_2CO), 4.14 (2H, t, *J* 7.0Hz, OCH_2), 6.30 (1H, d, *J* 19.5Hz, C<u>H</u>=CHSn), 7.74 (1H, d, *J* 19.5Hz, CH=C<u>H</u>Sn); δ_C (50.4MHz, DEPT) 180.42 (CO_2H), 165.28 (C=O), 152.49 (CH=<u>C</u>HSn), 136.50 (<u>C</u>H=CHSn), 64.61 (OCH_2), 33.96, 29.47, 29.30, 29.11, 28.52, 25.81, 24.54 (CH_2), 28.80, 27.08

($SnCH_2\underline{C}_2H_4$), 9.40 ($SnCH_2$) and 13.46 (CH_3); *m/z* (D.C.I., NH_3) 617 (MH^+, Sn^{120}, 28%), 615 (25), 559 (M^+-Bu, Sn^{120}, 100), 557 (70), 555 (40), 501 (18), 326 (40), 305 (32), 291 (29), 138 (29), 98 (31) and 55 (96).

Z-12-(3-tributylstannyl propenoate)-octadecanoic acid **4b**. The general procedure afforded **4b** (387mg, 86%) as a colourless oil from **3b** (461mg, 0.7mmol). $\nu_{max.}$ (thin film) 3600-3000 (br, w), 2970 (vs), 2920 (vs), 2858 (vs), 1712 (vs), 1590 (w), 1462 (m), 1438 (m), 1335 (m), 1205 (s), 1175 (m), 822 (m) and 740 (s); δ_H (200MHz) 0.78-1.04 (18H, m, ($C\underline{H}_3C_2H_4C\underline{H}_2)_3Sn$- and $C\underline{H}_3$), 1.04-1.74 (40H, m, $(C\underline{H}_2)_5OCH(C\underline{H}_2)_9$ and $(CH_3C_2\underline{H}_4CH_2)_3Sn$-), 2.30 (2H, t, *J* 7.5Hz, CH_2CO), 4.92 (1H, m, OCH), 6.72 (1H, d, *J* 13.0Hz, C<u>H</u>=CHSn), 7.15 (1H, d, *J* 13.0Hz, CH=C<u>H</u>Sn); δ_C (50.4MHz, DEPT) 180.54 (CO_2H), 167.98 (C=O), 157.18 (CH=<u>C</u>HSn), 135.80 (<u>C</u>H=CHSn), 74.48 (OCH), 34.05, 31.60, 29.34, 29.25, 29.08, 28.62, 25.12, 25.50, 22.42 (CH_2), 28.82, 27.22 ($SnCH_2\underline{C}_2H_4$), 10.85 ($SnCH_2$), 13.87 (CH_3) and 13.58 ($Sn(CH_2)_3\underline{C}H_3$); *m/z* (Direct, E.I.) 587 (M^+-Bu, Sn^{120}, 35%), 585 (25), 529 (18), 515 (40), 513 (30), 305 (34), 303 (29), 301 (15), 249 (15), 191 (10), 177 (10), 97 (20), 83 (23), 73 (23), 69 (38) and 55 (100).

E-12-(3-tributylstannyl propenoate)-tridecanoic acid **4c**. The general procedure afforded **4c** (403mg, 83%) as a colourless oil from **3c** (500mg, 0.85mmol). (Found: C, 58.62; H, 9.73. $C_{28}H_{54}O_4Sn$ requires C, 58.65; H, 9.49%); $\nu_{max.}$ (thin film) 3600-3000 (br, w), 2958 (s), 2922 (vs), 2850 (s), 1712 (s), 1590 (w), 1465 (m), 1262 (m), 1205 (m), 1160 (m) and 998 (w); δ_H (200MHz) 0.80-1.02 (15H, m, $(C\underline{H}_3C_2H_4C\underline{H}_2)_3Sn$-), 1.18-1.72 (33H, m, $(C\underline{H}_2)_9OCHC\underline{H}_3$ and $(CH_3C_2\underline{H}_4CH_2)_3Sn$-), 2.32 (2H, t, *J* 7.5Hz, CH_2CO), 4.96 (1H, m, OCH), 6.28 (1H, d, *J* 20.0Hz, C<u>H</u>=CHSn), 7.72 (1H, d, *J* 20.0Hz, CH=C<u>H</u>Sn); δ_C (50.4MHz, DEPT) 180.46 (CO_2H), 164.87 (C=O), 152.11 (CH=<u>C</u>HSn), 136.96 (<u>C</u>H=CHSn), 71.08 (OCH), 35.86, 33.96, 29.33, 29.23, 29.05, 25.26, 24.50 (CH_2), 28.80, 27.08 ($SnCH_2\underline{C}_2H_4$), 9.39 ($SnCH_2$), 13.87 (CH_3) and 13.44 ($Sn(CH_2)_3\underline{C}H_3$); *m/z* (C.I., NH_3) 575 (MH^+, Sn^{120}, 20%), 517 (M^+-Bu, Sn^{120}, 100), 515 (76), 513 (38), 345 (8), 305 (58), 303 (47), 214 (23), 191 (12), 138 (11), 108 (5), 96 (5), 73 (10), 69 (6) and 55 (48).

E-12-(3-tributylstannyl propenoate)-dodecanoic acid **4d**. The general procedure afforded **4d** (1.27g, 93%) as a colourless oil from **3d** (1.4g, 2.44mmol). (Found: C, 57.77; H, 9.46. $C_{27}H_{52}O_4Sn$ requires C, 57.97; H, 9.37%); $\nu_{max.}$ (thin film) 3600-3000 (br, w), 2958 (s), 2920 (vs), 2850 (s), 1710 (br, s), 1580 (w), 1462 (m), 1205 (m), 1155 (m) and 998 (w); δ_H (200MHz) 0.75-1.02 (15H, m, $(C\underline{H}_3C_2H_4C\underline{H}_2)_3Sn$), 1.18-1.74 (30H, m, $OCH_2(C\underline{H}_2)_9$ and $(CH_3C_2\underline{H}_4CH_2)_3Sn$-), 2.35 (2H, t, *J* 7.5Hz, CH_2CO), 4.14 (2H, t, *J* 7.0Hz, OCH_2), 6.30 (1H, d, *J* 19.5Hz, C<u>H</u>=CHSn), 7.75 (1H, d, *J* 19.5Hz, CH=C<u>H</u>Sn); δ_C (50.4MHz, DEPT) 180.46 (CO_2H), 165.35 (C=O), 152.69 (CH=<u>C</u>HSn), 136.57 (<u>C</u>H=CHSn), 64.65 (OCH_2), 33.99, 29.38, 29.15, 28.56, 28.50, 25.83, 24.56 (CH_2), 28.85, 27.12 ($SnCH_2\underline{C}_2H_4$), 9.44 ($SnCH_2$) and 13.51 (CH_3); *m/z* (D.C.I., NH_3) 561 (MH^+, Sn^{120}, 3%), 503 (M^+-Bu, Sn^{120}, 50), 501 (38), 305 (37), 301 (20), 291 (7), 270 (9), 253 (13), 181 (14), 111 (16), 98 (27), 83 (33), 69 (40) and 55 (100).

E-10-(3-tributylstannyl propenoate)-decanoic acid **4e**. The general procedure afforded **4e** (373mg, 89%) as a colourless oil from **3e** (991mg, 0.79mmol). $\nu_{max.}$ (thin film) 3600-3000 (w), 2960 (s), 2935 (vs), 2880 (s), 2862 (s), 1710 (br, s), 1588 (w), 1465 (m), 1215 (s), 1162 (m) and 998 (w); δ_H (200MHz) 0.78-1.02 (15H, m, $(C\underline{H}_3C_2H_4C\underline{H}_2)_3Sn$-), 1.20-1.75 (26H, m, $OCH_2(C\underline{H}_2)_7$ and $(CH_3C_2\underline{H}_4CH_2)_3Sn$-), 2.35 (2H, t, *J*

7.5Hz, CH_2CO), 4.14 (2H, t, *J* 7.0Hz, OCH_2), 6.30 (1H, d, *J* 20.0Hz, C<u>H</u>=CHSn), 7.74 (1H, d, *J* 20.0Hz, CH=C<u>H</u>Sn); δ_C (50.4MHz, DEPT) 180.40 (CO_2H), 165.28 (C=O), 152.66 (CH=<u>C</u>HSn), 135.46 (<u>C</u>H=CHSn), 64.54 (OCH_2), 33.91, 29.02, 28.50, 25.76, 24.47 (CH_2), 28.80, 27.08 ($SnCH_2\underline{C}_2H_4$), 9.40 ($SnCH_2$) and 13.46 (CH_3); *m/z* (C.I., NH_3) 533 (MH^+, Sn^{120}, 17%), 475 (M^+-Bu, Sn^{120}, 100), 473 (72), 471 (42), 417 (18), 305 (30), 289 (12), 242 (38), 136 (6), 98 (5), 69 (6) and 55 (62).

<u>E</u>-8-(3-tributylstannyl propenoate)-octanoic acid **4f**. The general procedure afforded **4f** (600mg, 87%) as a colourless oil from **3f** (713mg, 1.38mmol). (Found: C, 54.68; H, 9.03. $C_{23}H_{44}O_4Sn$ requires C, 54.69; H, 8.81%); $\nu_{max.}$ (thin film) 3600-3000 (br, m), 2950 (s), 2920 (s), 2865 (s), 2850 (s), 1709 (br, s), 1588 (w), 1462 (m), 1412 (m), 1255 (s), 1203 (s), 1152 (s) and 998 (m); δ_H (200MHz) 0.75-1.02 (15H, m, ($C\underline{H}_3C_2H_4C\underline{H}_2)_3Sn$-), 1.18-1.74 (22H, m, $OCH_2(C\underline{H}_2)_5$ and ($CH_3C_2\underline{H}_4CH_2)_3Sn$-), 2.35 (2H, t, *J* 7.5Hz, CH_2CO), 4.14 (2H, t, *J* 7.0Hz, OCH_2), 6.30 (1H, d, *J* 19.5Hz, C<u>H</u>=CHSn), 7.75 (1H, d, *J* 19.5Hz, CH=C<u>H</u>Sn); δ_C (50.4MHz, DEPT) 180.40 (CO_2H), 165.32 (C=O), 152.80 (CH=<u>C</u>HSn), 136.50 (<u>C</u>H=CHSn), 64.50 (OCH_2), 33.91, 28.49, 25.63, 24.43 (CH_2), 28.82, 27.11 ($SnCH_2\underline{C}_2H_4$), 9.44 ($SnCH_2$) and 13.48 (CH_3); *m/z* (D.C.I., NH_3) 505 (MH^+, Sn^{120}, 8%), 447 (M^+-Bu, Sn^{120}, 45), 445 (40), 443 (25), 305 (17), 271 (6), 232 (100), 215 (62), 214 (36), 197 (8), 142 (6), 124 (5), 96 (4) and 55 (13).

<u>E</u>-7-(3-tributylstannyl propenoate)-heptanoic acid **4g**. The general procedure afforded **4g** (450mg, 97%) as a colourless oil from **3g** (475mg, 0.95mmol). $\nu_{max.}$ (thin film) 3600-3000 (br, s), 2958 (vs), 2922 (vs), 2865 (s), 2850 (s), 1710 (br, vs), 1588 (m), 1462 (m), 1412 (m), 1375 (m), 1255 (m), 1205 (s), 1152 (s) and 998 (m); δ_H (200MHz) 0.78-1.02 (15H, m, ($C\underline{H}_3C_2H_4C\underline{H}_2)_3Sn$-), 1.18-1.75 (20H, m, $OCH_2(C\underline{H}_2)_4$ and ($CH_3C_2\underline{H}_4$-$CH_2)_3Sn$-), 2.36 (2H, t, *J* 7.5Hz, CH_2CO), 4.14 (2H, t, *J* 6.5Hz, OCH_2), 6.30 (1H, d, *J* 19.5Hz, C<u>H</u>=CHSn), 7.75 (1H, d, *J* 19.5Hz, CH=C<u>H</u>Sn); δ_C (50.4MHz, DEPT) 180.94 (CO_2H), 165.23 (C=O), 152.81 (CH=<u>C</u>HSn), 136.38 (<u>C</u>H=CHSn), 64.33 (OCH_2), 33.82, 28.53, 28.32, 25.47, 24.35 (CH_2), 28.79, 27.07 ($SnCH_2\underline{C}_2H_4$), 9.39 ($SnCH_2$) and 13.44 (CH_3); *m/z* (E.I.) 433 (M^+-Bu, Sn^{120}, 43%), 430 (32), 375 (18), 305 (100), 303 (76), 302 (43), 269 (22), 191 (24), 177 (26), 137 (12), 121 (17), 110 (11), 84 (32), 69 (20) and 55 (47).

<u>Z</u>-6-(3-tributylstannyl propenoate)-hexanoic acid **4h**. The general procedure afforded <u>Z</u>- **4h** (758mg, 90%) as a colourless oil from <u>Z</u>- **3h** (856mg, 1.75mmol). $\nu_{max.}$ (thin film) 3600-3000 (br, s), 2958 (vs), 2922 (vs), 2878 (s), 2858 (s), 1712 (br, vs), 1585 (w), 1465 (s), 1438 (m), 1375 (m), 1338 (s), 1235 (m), 1200 (vs), 1158 (m), 1062 (w), 960 (w), 875 (w) and 825 (s); δ_H (200MHz) 0.78-1.02 (15H, m, ($C\underline{H}_3C_2H_4C\underline{H}_2)_3Sn$-), 1.18-1.80 (18H, m, $OCH_2(C\underline{H}_2)_3$ and ($CH_3C_2\underline{H}_4CH_2)_3Sn$-), 2.34 (2H, t, *J* 7.5Hz, CH_2CO), 4.16 (2H, t, *J* 6.5Hz, OCH_2), 6.73 (1H, d, *J* 13.0Hz, C<u>H</u>=CHSn), 7.18 (1H, d, *J* 13.0Hz, CH=C<u>H</u>Sn); δ_C (50.4MHz, DEPT) 180.09 (CO_2H), 168.10 (C=O), 157.72 (CH=<u>C</u>HSn), 135.29 (<u>C</u>H=CHSn), 64.21 (OCH_2), 33.78, 29.03, 25.30, 24.17 (CH_2), 28.25, 27.21 ($SnCH_2\underline{C}_2H_4$), 10.82 ($SnCH_2$) and 13.58 (CH_3).

<u>E</u>-6-(3-tributylstannyl propenoate)-hexanoic acid **4h**. The general procedure afforded <u>E</u>- **4h** (907mg, 95%) as a colourless oil from <u>E</u>- **3i** (978mg, 2.0mmol). (Found: C, 53.25; H, 8.32. $C_{21}H_{40}O_4Sn$ requires C, 53.08; H, 8.46%); $\nu_{max.}$ (thin film) 3600-3000 (br, s), 2958 (vs), 2922 (vs), 2875 (s), 2850 (s), 1710 (br, vs),

1588 (w), 1462 (m), 1412 (m), 1375 (m), 1250 (s), 1205 (s), 1152 (s) and 998 (m); δ_H (200MHz) 0.78-1.02 (15H, m, ($C\underline{H}_3C_2H_4C\underline{H}_2)_3Sn$-), 1.18-1.80 (18H, m, $OCH_2(C\underline{H}_2)_3$ and ($CH_3C_2\underline{H}_4CH_2)_3Sn$-), 2.38 (2H, t, *J* 7.5Hz, CH_2CO), 4.15 (2H, t, *J* 6.5Hz, OCH_2), 6.30 (1H, d, *J* 19.5Hz, C<u>H</u>=CHSn), 7.75 (1H, d, *J* 19.5Hz, CH=C<u>H</u>Sn); δ_C (50.4MHz, DEPT) 179.95 (CO_2H), 165.18 (C=O), 152.92 (CH=<u>C</u>HSn), 136.34 (<u>C</u>H=CHSn), 64.15 (OCH_2), 33.75, 28.21, 25.33, 24.14 (CH_2), 28.80, 27.07 ($SnCH_2\underline{C}_2H_4$), 9.40 ($SnCH_2$)and 13.44 (CH_3); *m/z* (E.I.) 419 (M^+-Bu, Sn^{120}, 24%), 417 (17), 415 (10), 361 (18), 359 (14), 305 (66), 303 (51), 301 (28), 291 (10), 247 (14), 191 (10), 177 (13), 121 (13), 97 (8), 78 (18), 69 (26), 55 (100).

General method for Stille cross couplings. To a stirred solution of the desired substrate **4a-4h** (0.2mmol) in toluene (10mmol dm^{-3}) at -5°C under argon was added oxalyl chloride (2 equiv.) followed by catalytic DMF (5µl). The mixture was brought up to 10°C over 30min and then degassed with argon at this temperature for 10min. The solvent was then removed *in vacuo*, the residue obtained taken up in toluene (10ml) and solvent evaporated once more to afford the corresponding acid chloride **5a-5h**[22]. Couplings were performed in a glass Fisher Porter bottle. The vessel was charged with the palladium catalyst *trans*- benzyl-chlorobis(triphenyl-phosphine)palladium (II) (5mol%) in toluene (40ml) and flushed several times with carbon monoxide. The acid chloride **5a-5h** was then added *via* a syringe dissolved in toluene to a 4mmol dm^{-3} dilution. The bottle was flushed with carbon monoxide, pressurised to 3 atmospheres and transferred quickly to a preheated oil bath at 100°C and heated for 7-14h. Precipitation of metallic deposit signaled the reaction to be complete. The mixture was then cooled, vented, diluted with ether and filtered through Celite®. The filtrate was concentrated and the residue purified by column chromatography (SiO_2; 20% ether/petrol) and p.l.c.

<u>E</u>-4-Oxo-nonadec-2-en-19-olide **9a**. Obtained as a waxy solid (29.6mg, 48%) from *<u>E</u>*- **5a**. $\nu_{max.}$ ($CHCl_3$) 2930 (vs), 2860 (s), 1720 (s), 1698 (s), 1642 (w), 1626 (w), 1460 (m), 1370 (m), 1350 (m), 1308 (s), 1060 (br, m) and 980 (m); δ_H (200MHz) 1.28 (22H, br, s, C7-C17-$(H_2)_{11}$), 1.62-1.82 (4H, m, C6-H_2 and C18-H_2), 2.62 (2H, t, *J* 7.0Hz, C5-H_2), 4.29 (2H, t, *J* 5.0Hz, C19-H_2), 6.68 and 7.10 (2H, AB, *J* 16.0Hz, C2-H and C3-H); δ_C (50.4MHz, DEPT) 165.30 (<u>C</u>O_2R), 139.30 (CH=<u>C</u>H), 131.53 (<u>C</u>H=CH), 65.30 (OCH_2), 40.60 (<u>C</u>H_2CO), 28.47, 28.33, 28.24, 27.98, 27.63, 27.12, 25.30, 23.96 (CH_2); *m/z* (C.I., NH_3) 327 (21%), 326 (MNH_4^+, 100), 311 (65), 309 (MH^+, 60), 308 (15), 264 (15), 201 (5), 137 (12), 109 (13), 94 (15), 81 (11), 69 (5) and 58 (14).

<u>E</u>-4-Oxo-undecadec-2-en-15-olide **9b**. Obtained as a colourless oil (39mg, 58%) from *<u>Z</u>*- **5b**. $\nu_{max.}$ ($CHCl_3$) 2980 (s), 2930 (vs), 2860 (s), 1720 (vs), 1698 (vs), 1620 (m), 1460 (m), 1365 (m), 1270 (br, s), 1180 (s), 980 (s) and 912 (m); δ_H (200MHz) 0.88 (3H, <u>ca</u>. t, *J* 6.0Hz, C21-H_3), 1.05-1.80 (28H, m, C6-C14-$(H_2)_9$, and $CH_3(C\underline{H}_2)_5$), 2.46-2.72 (2H, m, C5-H_2), 4.98-5.12 (1H, m, C15-H), 6.68 and 7.21 (2H, AB, *J* 16.0Hz, C2-H and C3-H); δ_C (50.4MHz, DEPT) 165.53 (<u>C</u>O_2R), 137.91 (CH=<u>C</u>H), 131.55 (<u>C</u>H=CH), 75.96 (OCH), 42.20 (<u>C</u>H_2CO), 34.07, 32.50, 31.56, 28.98, 27.52, 27.41, 26.72, 26.48, 25.30, 24.27, 23.07, 22.39 (CH_2), 13.87 (CH_3); *m/z* (C.I., NH_3) 356 (32%), 354 (MNH_4^+, 34), 339 (100), 337 (MH^+, 76), 319 (16), 251 (6), 116 (8), 109 (9), 95 (12), 81 (15) and 55 (19).

<u>E</u>-4-Oxo-hexadec-2-en-15-olide **9c**[18]. Obtained as a colourless oil (37.2mg, 70%) from *<u>E</u>*- **5c**. $\nu_{max.}$ ($CHCl_3$) 2980 (s), 2932 (vs), 2860 (s), 1720 (vs), 1698 (s), 1620 (m), 1460 (m), 1380 (w), 1365 (m), 1265

(br, m), 1180 (m), 1030 (m) and 980 (s); δ_H (200MHz) 1.15-1.50 (14H, m, C7-C13-$(H_2)_7$) 1.30 (3H, d, *J* 6.5Hz, C16-H_3), 1.50-1.85 (4H, m, C6-H_2 and C14-H_2), 2.43-2.70 (2H, m, C5-H_2), 5.01-5.16 (1H, m, C15-H), 6.66 and 7.20 (2H, AB, *J* 16.0Hz, C2-H and C3-H); δ_C (50.4MHz, DEPT) 165.32 ($\underline{C}O_2R$), 137.73 (CH=$\underline{C}$H), 131.55 ($\underline{C}$H=CH), 72.42 (OCH), 42.15 ($\underline{C}H_2CO$), 34.37, 27.45, 26.66, 26.54, 24.23, 23.34 (CH_2), 19.93 (CH_3); *m/z* (C.I., NH_3) 286 (28%), 284 (MNH_4^+, 38), 269 (100), 267 (MH^+, 45), 253 (10), 109 (3), 96 (3) and 58 (3).

E-4-Oxo-pentadec-2-en-15-olide **9d**. Obtained as a colourless oil (26.7mg, 53%) from *E*- **5d**. (Found: C, 71.57; H, 10.01. $C_{15}H_{24}O_3$ requires C, 71.39; H, 9.59%); $\nu_{max.}$ ($CHCl_3$) 2930 (vs), 2860 (s), 1728 (vs), 1698 (s), 1642 (w), 1620 (w), 1460 (m), 1380 (w), 1260 (br, m), 1175 (m), 1030 (w) and 980 (s); δ_H (200MHz) 1.10-1.56 (14H, m, C7-C13-$(H_2)_7$), 1.56-1.80 (4H, m, C6-H_2 and C14-H_2), 2.56 (2H, t, *J* 7.0Hz, C5-H_2), 4.30 (2H, t, *J* 5.5Hz, C15-H_2), 6.66 and 7.21 (2H, AB *J* 16.0Hz, C2-H and C3-H); δ_C (50.4MHz, DEPT) 165.38 ($\underline{C}O_2R$), 137.91 (CH=$\underline{C}$H), 131.10 ($\underline{C}$H=CH), 65.47 (OCH_2), 41.98 ($\underline{C}H_2CO$), 27.42, 27.19, 26.98, 26.58, 25.16, 24.02 (CH_2); *m/z* (C.I., NH_3) 270 (MNH_4^+, 47%), 256 (18), 255 (100), 239 (18), 208 (15), 158 (14), 109 (15), 96 (18), 81 (24), 69 (14), 58 (15) and 55 (36).

E-4-Oxo-tridec-2-en-13-olide **9e**. Obtained as a colourless oil (24.6mg, 55%) from *E*- **5e**. $\nu_{max.}$ ($CHCl_3$) 2930 (vs), 2860 (s), 1722 (vs), 1692 (vs), 1620 (m), 1460 (m), 1370 (w), 1350 (m), 1308 (m), 1265 (s), 1070 (m), 1045 (m) and 980 (m); δ_H (200MHz) 1.25-1.82 (14H, m, C6-C12-$(H_2)_7$), 2.54 (2H, t, *J* 7.0Hz, C5-H_2), 4.32 (2H, t, *J* 5.5Hz, C13-H_2), 6.61 and 7.41 (2H, AB, *J* 16.0Hz, C2-H and C3-H); δ_C (50.4MHz, DEPT) 200.81 ($\underline{C}$=O), 165.07 ($\underline{C}O_2R$), 137.91 (CH=$\underline{C}$H), 130.32 ($\underline{C}$H=CH), 66.53 (OCH_2), 43.06 ($\underline{C}H_2CO$), 28.45, 27.33, 26.69, 26.59, 26.41, 23.54 (CH_2); *m/z* (C.I., NH_3) 245 (30%), 244 (100), 242 (MNH_4^+, 45), 227 (90), 225 (MH^+, 48), 224 (15), 211 (35), 181 (16), 82 (12) and 58 (12).

Z-4-Oxo-undec-2-en-11-olide **9f**. Obtained as a colourless oil (16mg, 41%) from *E*- **5f**. $\nu_{max.}$ ($CHCl_3$) 2968 (s), 2958 (s), 2860 (m), 1705 (s), 1620 (m), 1460 (m), 1392 (m), 1375 (m), 1355 (m), 1290 (s), 1155 (m), 1112 (m), 1100 (m), 1058 (m), 998 (m), 962 (m) and 878 (w); δ_H (200MHz) 1.28-1.86 (10H, m, C6-C10-$(H_2)_5$), 2.69 (2H, t, *J* 6.0Hz, C5-H_2), 4.21 (2H, t, *J* 6.0Hz, C11-H_2), 5.94 and 6.55 (2H, AB *J* 13.0Hz, C2-H and C3-H); δ_C (50.4MHz, DEPT) 203.16 (C=O), 164.93 ($\underline{C}O_2R$), 142.23 (CH=$\underline{C}$H), 123.69 ($\underline{C}$H=CH), 67.82 (OCH_2), 39.80 ($\underline{C}H_2CO$), 26.60, 24.48, 24.05, 23.26, 20.42 (CH_2); *m/z* (C.I., NH_3) 216 (18%), 214 (MNH_4^+, 100), 197 (MH^+, 62) and 179 (3).

Z-4-Oxo-dec-2-en-10-olide **9g**. Obtained as a colourless oil (11.6mg, 32%) from *E*- **5g**. $\nu_{max.}$ ($CHCl_3$) 2970 (s), 2958 (s), 2860 (m), 1708 (s), 1623 (m), 1465 (m), 1375 (m), 1355 (m), 1295 (m), 1155 (m), 1100 (m), 1058 (m), 998 (m), 962 (m) and 878 (w); δ_H (200MHz) 1.20-1.86 (8H, m, C6-C9-$(H_2)_4$), 2.64 (2H, t, *J* 6.0Hz, C5-H_2), 4.28 (2H, t, *J* 6.0Hz, C10-H_2), 6.03 and 6.52 (2H, AB *J* 13.0Hz, C2-H and C3-H); *m/z* (C.I., NH_3) 202 (15%), 200 (MNH_4^+, 100), 183 (MH^+, 45).

Z-4-Oxo-non-2-en-9-olide **9h**. Obtained as a colourless oil (5.2mg, 15%) from *Z*- **5h**. $\nu_{max.}$ ($CHCl_3$) 3023 (m), 2937 (m), 1728 (vs), 1698 (s), 1611 (w), 1449 (w), 1386 (w), 1357 (w), 1288 (m), 1228 (m), 1187 (m), 1175 (m), 1085 (m), 1048 (m), 860 (m) and 817 (m); δ_H (200MHz) 1.62-1.98 (6H, m, C6-C8-$(H_2)_3$),

2.58 (2H, t, *J* 6.0Hz, C5-H_2), 4.22 (2H, ca. t, *J* 6.0Hz, C9-H_2), 6.03 and 6.52 (2H, AB, *J* 13.0Hz, C2-H and C3-H); *m/z* (C.I., NH_3) 169 (MH^+, 22), 151 (18), 123 (12), 114 (18), 109 (32), 100 (52), 99 (100), 96 (28), 82 (58), 68 (38) and 55 (98).

E, E-1,11-dioxa-2,5,12,15-tetraoxo-decadec-3,13-diene **9i**. Obtained as a waxy solid (19.5mg, 58%) from *E*- **5h** [and from *Z*-**5h** in 38% yield]. $\nu_{max.}$ ($CHCl_3$) 2958 (vs), 2940 (vs), 2865 (s), 1722 (vs), 1698 (vs), 1640 (m), 1625 (m), 1458 (m), 1385 (m), 1305 (m), 1285 (vs), 1175 (s), 1130 (m), 1075 (m), 1042 (m) and 980 (s); δ_H (200MHz) 1.32-1.50 (4H, m), 1.60-1.82 (8H, m), 2.62 (4H, t, *J* 7.0Hz, C6, C16-H_2), 4.26 (4H, t, *J* 6.0Hz, C10, C20-H_2), 6.64 and 7.07 (4H, 2xAB, *J* 16.0Hz, C3,C4-H, C_{13},C_{14}-H); δ_C (50.4MHz, DEPT) 200.94 (C=O), 165.65 (<u>C</u>O_2R), 139.40 (CH=<u>C</u>H), 131.16 (<u>C</u>H=CH), 64.88 (OCH_2), 41.07 (<u>C</u>H_2CO), 27.74, 25.42, 24.47 (CH_2); *m/z* (C.I., NH_3) 354 (MNH_4^+, 92%), 337 (MH^+, 53), 242 (12), 206 (12), 186 (40), 170 (60), 152 (100), 151 (62), 132 (62), 112 (58), 96 (64), 84 (81), 70 (68) and 58 (58).

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