Natural Acetylenes. Part XXXIX.[1] Synthesis of Methyl [1,9-^{14}C]-, [9-^{14}C]-, and [10-^{3}H]-Crepenynate, Methyl [9-^{14}C]- and [10-^{3}H]-Linoleate, and Methyl [9-^{14}C]- and [10-^{3}H]-Oleate [2]

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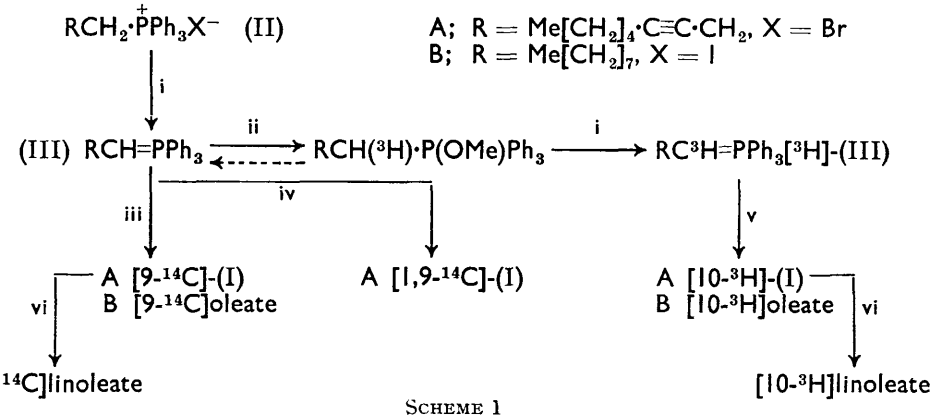
Specifically labelled methyl crepenynate and oleate have been synthesised from the C_9 phosphoranes, $Me[CH_2]_4\cdot C{\equiv}C\cdot CH_2\cdot CH{=}PPh_3$ and $Me[CH_2]_7\cdot CH{=}PPh_3$, respectively, and the C_9 aldehyde ester, $OCH\cdot[CH_2]_7\cdot CO_2Me$; methyl linoleate has been obtained by partial hydrogenation of the crepenynate. Carbon-14 was introduced into the C_{18} esters *via* the [9-^{14}C]- and [1,9-^{14}C]-aldehyde esters, and tritium *via* a reaction of the phosphoranes with tritiated methanol. Several routes to the labelled C_9 aldehyde ester are described.

THE need for specifically labelled methyl crepenynate (I) for biosynthetic studies in the polyacetylene field led to the recently developed synthesis [3] in which the

$$Me[CH_2]_4\cdot C{\equiv}C\cdot CH_2\cdot CH\overset{c}{=}CH\cdot[CH_2]_7\cdot CO_2Me \qquad (I)$$

cis-double bond formation by a Wittig reaction represented the last and crucial stage. This has now been used to prepare both carbon-14 and tritium labelled methyl crepenynate, methyl linoleate (by partial hydrogenation of the crepenynate), and methyl oleate (Scheme 1).



SCHEME 1

Reagents: i, Bu^{n}Li; ii, MeO^{3}H; iii, O^{14}CH·[CH$_2$]$_7$·CO$_2$Me{[9-^{14}C]-(IV)}; iv, O^{14}CH·[CH$_2$]$_7$·^{14}CO$_2$Me {[1,9-^{14}C]-(IV)}; v, OCH·[CH$_2$]$_7$·CO$_2$Me (IV); vi, H$_2$–Pd (Lindlar).

The yields of methyl crepenynate in the small scale Wittig reactions used with labelled materials generally ranged from 40 to 50% (*cf.* ref. 3; 51%) and none of the *trans*-isomer was detectable. Up to 18% of the *trans*-isomer was formed, however, in the corresponding oleate synthesis and the product had to be purified on silver nitrate-impregnated silica gel layers.

Tritium was introduced at C-10 of the C_{18} esters by careful addition of tritiated methanol to the phosphorane (III) [4] until its colour had almost disappeared and regeneration of the phosphorane with butyllithium before the aldehyde was added {Scheme 1; sequence (III) to [^{3}H]-(III)}. This gave both high yields of the unsaturated esters and satisfactory tritium activities; omission of the second butyl-lithium addition resulted in lower crepenynate and oleate yields.

The specificity of tritium labelling for crepenynate and linoleate must have been close to 100% as suggested by incorporation experiments with the fungus *Clitocybe rhizophora* [5] in which the activity of the metabolite (V) was restricted to C-1.

$$CH_3\cdot CH_2\cdot CH(OH)\cdot[C{\equiv}C]_2\cdot CH(OH)\cdot CH_2\cdot OH \qquad (V)$$

Carbon-14 was introduced into the C_{18} esters *via* the C_9 aldehyde esters [1,9-$^{14}C_2$]-(IV) and [9-^{14}C]-(IV) (Scheme 1), an approach which was determined by the ready availability of *cis,trans*-[1-^{14}C]linolenic and [1-^{14}C]elaidic acid. Several alternative sequences of standard reactions for obtaining the [^{14}C]labelled aldehyde esters (IV) were examined; the reactions of Scheme 2 were eventually used for doubly-labelled (IV) ([1,9-^{14}C]) whilst those of Scheme 3 served in the preparation of the singly labelled (IV) ([9-^{14}C]). The selective reduction of the C_9 half-ester (VII) *via* the

[1] Part XXXVIII, Sir Ewart R. H. Jones, J. W. Keeping, M. G. Pellatt, and V. Thaller, preceding paper.

[2] A more detailed account of the work described in this paper is in the D.Phil. Theses of R. A. Vere Hodge, Oxford 1969, and G. C. Barley, Oxford 1971.

[3] R. W. Bradshaw, A. C. Day, Sir Ewart R. H. Jones, C. B. Page, V. Thaller, and R. A. Vere Hodge, *J. Chem. Soc.* (*C*), 1971, 1156.

[4] H. J. Bestmann, O. Kratzer, and H. Simon, *Chem. Ber.*, 1962, **95**, 2750, have used tritiated ethanol for the introduction of tritium onto a double bond *via* the phosphorane in a Wittig reaction.

[5] G. C. Barley, A. C. Day, U. Graf, Sir Ewart R. H. Jones, I. O'Neill, R. Tachikawa, V. Thaller, and R. A. Vere Hodge, *J. Chem. Soc.* (*C*), 1971, 3308.

acid chloride with lithium hydridotri-t-butoxyaluminate [6] was difficult to carry out on the very small scale required and the yields of the aldehyde ester (IV) were variable and unpredictable (5—40%). The alternative approach, which involved the oxidation of the bromoalkene with trimethylamine *N*-oxide,[7] gave acceptable yields of the aldehyde ester (IV) which were easily reproducible, and is the preferred method.

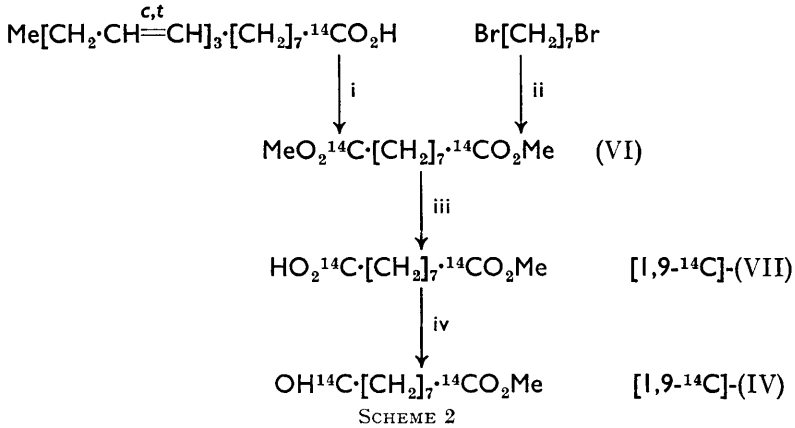
EXPERIMENTAL

Equipment used: i.r., Perkin-Elmer 157 and Unicam SP 200; n.m.r., Perkin-Elmer R10 and R14; m.p. (corr.) Kofler hot-stage apparatus.

G.l.c.: poly(ethylene glycol succinate) (10%) on Embacel (1500 × 4 mm) with argon (50 ml min^{-1}) was used generally. FFAP (15%) on Celite (2100 × 4 mm) with argon was used for gas-radiochromatography [8] of the [9-^{14}C]-C_{18}-esters.

Petrol refers to light petroleum, b.p. 30—40°, redistilled from phosphorus pentoxide. Dimethylformamide (DMF) was dried over Linde 4A molecular sieve. Tetrahydrofuran (THF) and dimethoxyethane (DME) were dried and purified by refluxing over $LiAlH_4$. All evaporations were carried out under reduced pressure.

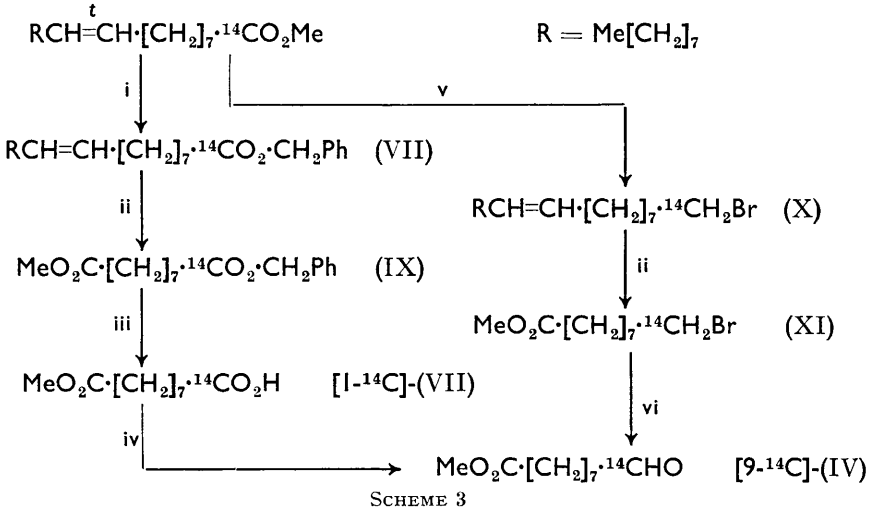
The radioactive samples were counted on a Liquid Scintillation System (Beckman Instruments Inc., type LS100) fitted with a direct Data Readout Module. A



SCHEME 2

Reagents: i, $KMnO_4$–$NaIO_4$, CH_2N_2; ii, $K^{14}CN$, HO^-, MeOH–H^+; iii, $Ba(OH)_2$ (0·5 mol. equiv.); iv, $SOCl_2$, $LiAl(Bu^tO)_3H$

Liquid chromatography: SiO_2 H.B.L. M60 in columns and Merck $HF_{254+366}$ in 0·3 mm (t.l.c.) and Merck $PF_{254+366}$ in 1 mm (p.l.c.) layers. SiO_2 $PF_{254+366}$ (150 g) and aqueous silver nitrate (10%, 180 ml) were used in the preparation of solution (10 ml) of 5-(biphenyl-4-yl)-2-(4-t-butylphenyl)-1,3,4-oxadiazole (6·00 g) in AnalaR toluene (1 l) was used as scintillator. Counting efficiencies of 43—55 and 88—90% were found for ^{3}H and ^{14}C, respectively. They were



SCHEME 3

Reagents: i, HO^-, $PhCHN_2$; ii, $KMnO_4$-$NaIO_4$, CH_2N_2; iii, H_2–Pd; iv, $SOCl_2$, $LiAl(OBu^t)_3H$; v, $LiAlH_4$, Ph_3PBr_2; vi, Me_3NO

layers (5 plates 20 × 20 cm) for argentation p.l.c., for which the layers were activated at 100° for 20 min prior to use.

measured for varying degrees of quench by quenching standard samples of [1-^{14}C]- and [1,2-^{3}H]-$C_{16}H_{34}$ with $CHCl_3$.

[6] H. C. Brown and R. F. McFarlin, *J. Amer. Chem. Soc.*, 1958, **80**, 5375.

[7] V. Franzen and S. Otto, *Chem. Ber.*, 1961, **94**, 1360.

[8] A. T. James and E. Piper, *Analyt. Chem.*, 1963, **35**, 515; A. T. James and C. Hitchcock, *Kerntechnik*, 1965, **7**, 5.

All reactions were carried out repeatedly with 'cold' materials prior to the radioactive syntheses. The purity of the radioactive samples was ascertained by direct t.l.c. and g.l.c. comparison with authentic specimens.

Nonyltriphenylphosphonium Iodide (IIB).—1-Iodononane [prepared from 1-bromononane (4·14 g, 20 mmol) and NaI (4·95 g, 25 mmol) in Me_2CO], and Ph_3P (6·28 g, 24 mmol) in C_6H_6 (70 ml) were heated under reflux for 24 h. Trituration of the concentrated reaction mixture with Et_2O and crystallisation from Me_2CO–Et_2O yielded yellow prisms of nonyltriphenylphosphonium iodide (8·2 g, 15·0 mmol, 79%), m.p. 80—80·5°.

Non-3-ynyltriphenylphosphonium bromide (IIA) melted at 146—147° (lit.,[3] 133·5—134°) with a change of form at 133·5—134°.

General Procedure for the Wittig Reaction.—For the synthesis of carbon-14 labelled esters the operations described [3] were carried out with 0·03—0·2 mmol of Wittig salt suspended in Et_2O (10 ml). The colour which developed with BuLi (0·85 equiv.) for these low phosphorane concentrations was yellow to faintly red. On addition of the aldehyde (0·7 equiv.) the mixture was stirred for 0·5 h before dil. HCl was added and the Et_2O layer worked up (heating under reflux and filtration were omitted). The yields (40—50% based on the aldehyde ester) refer to p.l.c. purified esters (petrol–Et_2O, 9 : 1, for crepenynate and argentation p.l.c. with the same solvent system for oleate).

For tritium labelling the reaction was carried out on 1—3 mmol of the Wittig salt. The phosphorane produced on BuLi addition was stirred for 10 min before tritiated MeOH (up to 0·8 equiv.) was added carefully: the colour of the mixture was not quite discharged and a thick white precipitate formed. The phosphorane was then regenerated with BuLi (0·85 equiv.) and the sequence of operations was continued as in the case of carbon-14 labelling.

Synthesis of the Tritium-labelled Esters (*Scheme* 1). [^{3}H]*Methanol.* This was prepared as for MeO^2H.[9] $(MeO)_2CO$ (6·0 g), ^3H_2O (1·5 ml; 2·6 Ci, sp. act. 31 Ci mol^{-1}; Radiochemical Centre, Amersham) and $(MeO)_2SO_2$ (0·1 ml) were heated under reflux for 3 days. Distillation afforded MeO^3H (1·5 ml; 1 Ci, sp. act. 12 Ci mol^{-1}). Addition of dry MeOH to the residue and repeated distillation gave additional amounts of less active MeO^3H.

Methyl [10-^{3}H]*Crepenynate* {[10-^{3}H]-(I)}.—Phosphonium bromide (IIA) (1·39 g, 3·05 mmol), MeO^3H (0·09 ml; 2·3 mmol, 28 mCi), and the adehyde ester (IV) (0·4 g, 2·15 mmol) yielded methyl [10-^{3}H]crepenynate (284 mg; 5·15 mCi, sp. act. 5·3 mCi mmol^{-1}; tritium yield 18%).

Methyl [10-^{3}H]*linoleate.* Methyl [10-^{3}H]crepenynate (71·5 mg, 1·27 mCi) in ethanol (2 ml) was hydrogenated over Lindlar catalyst (120 mg) in the presence of quinoline (120 mg) in a Hösli microhydrogenator until 1 mol. equiv. H_2 had been taken up. Purification by argentation p.l.c. (petrol–Et_2O, 9 : 1) afforded a major zone (R_F 0·35) which contained methyl [10-^{3}H]linoleate (1·19 mCi, 93%, sp. act. 5·3 mCi mmol^{-1}).

Methyl [10-^{3}H]*Oleate.* The phosphonium iodide (IIB) (500 mg, 0·97 mmol), MeO^3H (0·03 ml; 0·75 mmol, 9 mCi), and the aldehyde ester (IV) (127 mg, 0·68 mmol) yielded methyl [10-^{3}H]oleate (169 mg; 2·91 mCi, sp. act. 5·1 mCi mmol^{-1}; tritium yield 32%).

Synthesis of Methyl [1,9-^{14}C]*Crepenynate* (*Schemes* 2 *and* 1).—*Dimethyl* [1,9-^{14}C]*azelate* (VI). (*a*) *cis,trans*-[1-^{14}C]Linolenic acid (5·88 mCi, sp. act. 41 mCi mmol^{-1}; Radiochemical Centre, Amersham) in C_6H_6 (1 ml) was added to a stirred mixture of stock oxidant solution [10] [77 ml; prepared from $NaIO_4$ (20·86 g) and $KMnO_4$ (0·4 g) in H_2O (1 l)], K_2CO_3 (96 mg), Bu^tOH (40 ml), and H_2O (80 ml) under N_2 and stirring was continued for 20 h at 20°. $Na_2S_2O_5$ was then added until a clear yellow solution was obtained; this was acidified and concentrated, H_2O (100 ml) was added to the residue, and the mixture was concentrated again. The residue was extracted continuously (24 h) with Et_2O, the extract was concentrated to 50 ml, treated with excess of CH_2N_2 in Et_2O, and the crude product was purified by p.l.c. (petrol–EtOAc, 8 : 1) and gave a single zone (R_F 0·32). This yielded on extraction dimethyl [1,9-^{14}C]azelate (5 mCi, 85%), t_R (153°) 9·5 min.

(*b*) K^{14}CN (5 mCi, sp. act. 22·5 mCi mmol^{-1}; Radiochemical Centre, Amersham) in H_2O (0·25 ml) and 1,7-dibromoheptane (51 mg, 0·095 mmol) in EtOH (0·2 ml) were mixed, sealed in a Carius tube, and heated at 100° for 24 h. The mixture was then kept at 20° for 0·5 h with HCl (N; 2 ml). KOH (0·2 g) in H_2O (0·5 ml) was then added and the tube was re-sealed, and heated at 100° for another 24 h. The mixture was concentrated and the pale yellow solid was dissolved in H_2SO_4–MeOH (4% v/v; 5 ml) and heated under reflux for 4 h. Isolation with Et_2O and purification by p.l.c. [see under (*a*)] gave dimethyl [1,9-^{14}C]azelate (2·94 mCi, 59%).

Monomethyl [1,9-^{14}C]*azelate* {[1,9-^{14}C]-(VII)}. The diester (0·06 mmol; 2·5 mCi, sp. act. 41 mCi mmol^{-1}) and $Ba(OH)_2$–MeOH (0·2M; 0·31 ml, 0·06 mmol) were stirred under N_2 (conical flask fitted with syringe cap and magnetic stirrer) for 3 h at 20°. The crystalline precipitate which formed was first washed with petrol [recovery of unchanged diester (VI); 1 mCi, 40%] and then suspended in HCl (2N; 0·2 ml) and Et_2O (10 ml). The Et_2O layer was dried, concentrated, and purified by p.l.c. (petrol–Et_2O–AcOH, 58 : 40 : 2): the band with R_F 0·3 gave monomethyl [1,9-^{14}C]azelate (1·2 mCi, 48%), m.p. 20—21° (lit.,[11] 22—24°); azelaic acid (0·3 mCi, 12%) was recovered from a more polar band. The by-products were recycled once and an additional 0·35 mCi of the half-ester was obtained. Total activity yield in the hydrolysis step was thus 62%; the overall yield from [1-^{14}C]linolenic acid was 53% and from K^{14}CN, 36·5%.

Methyl 8-*formyl*[1,9-^{14}C]*octanoate* {[1,9-^{14}C]-(IV)}. The half-ester [1,9-^{14}C]-(VII) (1·55 mCi, sp. act. 41 mCi mmol^{-1}), DME (10 ml), and $SOCl_2$ (0·1 ml) were mixed at 0° and then heated under reflux for 0·5 h. Half the solvent was distilled off; the residual solution was diluted with THF (5 ml) and cooled to −78°. To this was added under N_2 with stirring during 1 h a solution (1 ml) of $LiH(OBu^t)_3$ [6] in DME (20 mg ml^{-1}; 0·078 mmol). After another 1 h at −78°, NH_4Cl (20 mg) and H_2O (0·1 ml) were added and the mixture was allowed to warm slowly to 20°. The solvent was distilled off under vacuum (fractionating column) and the residue was dissolved in Et_2O and purified by p.l.c. (petrol–Et_2O, 2 : 1). The band with R_F 0·31 yielded methyl 8-formyl[1,9-^{14}C]octanoate (0·86 mCi, 55%), t_R (158°) 8 min.

Methyl [1,9-^{14}C]*crepenynate* {[1,9-^{14}C]-(I)} (*Scheme* 1). The aldehyde ester [1,9-^{14}C]-(IV) (0·86 mCi, sp. act. 41 mCi mmol^{-1}) and the Wittig salt (IIA) yielded methyl

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[10] E. von Rudloff, *Canad. J. Chem.*, 1956, **34**, 1413.

[11] A. Noller, *J. Amer. Chem. Soc.*, 1926, **48**, 1078.

[1,9-^{14}C]crepenynate (0·37 mCi, 43%). Overall activity yield from [1-^{14}C]linolenic acid was 12·5% and from K^{14}CN 8%.

Syntheses of the [9-^{14}C]-C_{18}-*Esters* (*Schemes* 3 *and* 1).—*Benzyl elaidate* (VIII), b.p. 169° at 0·05 mmHg, n_D^{20} 1·4923 (Found: C, 80·8; H, 10·95. $C_{25}H_{40}O_2$ requires C, 80·6; H, 10·8%), $\nu_{max.}$ (film) 1740 (ester CO), 1600, 1500 (Ph), and 975 cm^{-1} (*trans*-CH=CH), τ (CCl_4) 9·07 (m, CH_3·CH_2), 8·6—8·8br (m, [CH_2]$_6$·CH_2·CH=CH·CH_2·[CH_2]$_6$), 8·0 (m, CH_2·CH=CH·CH_2), 7·78 (t, J 6 Hz, CH_2·CO_2·CHPh), 5·0 (s, CH_2Ph), 4·65br (m, CH=CH), and 2·7 (s, Ph). *Methyl benzyl azelate* (IX) (Found: C, 69·6; H, 8·4. $C_{17}H_{24}O_4$ requires C, 69·85; H, 8·25%), $\nu_{max.}$ (CCl_4) 1738 (ester CO), 1600 and 1495 cm^{-1} (Ph), τ (CCl_4) 8·5—8·7 (m, [CH_2]$_5$), 7·72br (m, CH_2·CO_2R), 6·4 (s, CO_2·CH_3), 4·98 (s, CH_2Ph), and 2·72 (s, Ph). Elaidyl bromide (X), $\nu_{max.}$ (film) 975 cm^{-1} (*trans*-CH=CH), τ (CCl_4) 9·07 (m, CH_3·CH_2), 8·8 (m, [CH_2]$_6$·CH_2·CH=CH·CH_2·[CH_2]$_6$), 8·03 (m, CH_2·CH=CH·CH_2), 6·65 (t, J 7 Hz, CH_2·CH_2Br), and 4·65 (m, CH_2·CH=CH·CH_2). Methyl 9-bromononanoate (XI), b.p. 80—82° at 0·3 mmHg, n_D^{20} 1·4563 (lit.,[12] n_D^{22} 1·4570), $\nu_{max.}$ (film) 1742 cm^{-1} (ester CO), τ (CCl_4) 8·62 (m, [CH_2]$_5$), 7·75 (m, CH_2·CO_2Me), 6·64 (t, J 6 Hz, CH_2·CH_2Br), and 6·38 (s, CO_2·CH_3).

Methyl 8-*formyl*[9-^{14}C]*octanoate* {[9-^{14}C]-(IV)} (*Scheme* 3). (*a*) Methyl elaidate (20 mCi, sp. act. 58 mCi mmol^{-1}; Radiochemical Centre, Amersham) was hydrolysed with KOH–MeOH (5% w/v) to elaidic acid (20 mCi). To this in Et_2O (3 ml) was added dropwise at 0° and with stirring an Et_2O solution of excess of $PhCHN_2$ [prepared from NaOMe and TsN(NO)·CH_2Ph [13]]; the temperature of the mixture was brought to 20° over 2 h and stirring was continued for 24 h. Concentration of the mixture and p.l.c. of the residue (petrol–Et_2O, 9 : 1) gave benzyl [1-^{14}C]elaidate (R_F 0·6; 19·7 mCi, 98·5%). This, K_2CO_3 (17 mg), stock oxidant solution [10] (20 ml; *cf.* oxidation of linolenic acid), Bu^{t}OH (30 ml), and H_2O (60 ml) were stirred vigorously for 48 h at 40° and cooled; $Na_2S_2O_5$ was added till the solution became colourless. It was then acidified (pH 2—3) (10% H_2SO_4), concentrated to *ca.* 20 ml, and continuously extracted with Et_2O for 48 h. The concentrated extract was esterified with CH_2N_2 in Et_2O. The resulting oil was purified by p.l.c. (petrol–EtOAc, 2 : 1): the more polar zone (R_F 0·5) afforded on elution methyl benzyl [1-^{14}C]azelate (19·3 mCi, 98%). This was hydrogenated over 5% Pd–C (300 mg) in dry Et_2O (60 ml) for 10 h at 25° and gave monomethyl [1-^{14}C]azelate (19·1 mCi, 99%). Part of this (3·12 mCi) was converted (*cf.* chlorination and reduction [6] described for Scheme 2) to methyl 8-formyl[9-^{14}C]octanoate (0·465 mCi, sp. act. 58 mCi mmol^{-1}, 15%). Overall yield from methyl [1-^{14}C]-elaidate was 14·5%.

(*b*) Methyl [1-^{14}C]elaidate (10·9 mCi, sp. act. 60 mCi mmol^{-1}) in dry Et_2O (5 ml) was added during 15 min to a stirred suspension of $LiAlH_4$ (40 mg) in Et_2O (15 ml) under N_2 at 24°. Stirring was continued for 0·5 h, the mixture was then heated under reflux for 1 h, cooled, and excess of reagent was decomposed with water. H_2SO_4 (10%; 0·25 ml) was added, the product was isolated with Et_2O and the extract was purified by p.l.c. (petrol–Et_2O, 2 : 1); the single band (R_F 0·4) gave on extraction [1-^{14}C]-elaidyl alcohol (10·8 mCi, 99%) which was diluted with 'cold' material (109 mg). The resulting [1-^{14}C]elaidyl alcohol (10·8 mCi, sp. act. 20 mCi mmol^{-1}, 0·61 mmol) in DMF (15 ml) was added in one portion to a Ph_3PBr_2 [14] solution [4·6 ml, 0·9 mmol; prepared from Br_2 (3·12 g) and Ph_3P (7·53 g) in DMF (100 ml)] stirred at 5° under N_2. Stirring was continued first at 5° for 0·5 h and then at 23° for 12 h. The products were extracted with petrol and the extract was chromatographed on a SiO_2 column (40 g). The first 200 ml of petrol eluted [1-^{14}C]elaidyl bromide (9·6 mCi, 89%). This was oxidised with $KMnO_4$–$NaIO_4$ at 40° and the product was isolated and methylated as described under (*a*). The concentrated bromo-ester solution was purified by p.l.c. (petrol–Et_2O, 9 : 1): the band with R_F 0·55 afforded on extraction methyl 9-bromo-[9-^{14}C]nonanoate (7 mCi, 0·35 mmol, 73%). The latter and Me_3NO (39·4 mg, 0·525 mmol; dehydrated immediately before use by heating first at 120° and 0·1 mmHg, and then by slowly raising the temp. to 180°) in dry $CHCl_3$ (3 ml) were heated under reflux for 2 h in the dark.[7] The mixture was concentrated (vacuum; 20°), Et_2O (10 ml) was added to the oily residue, and the precipitated solid was filtered off and washed with Et_2O (3 × 5 ml). The filtrate and washings were combined and concentrated, and the residue was purified by p.l.c. (petrol–Et_2O, 2 : 1). Two bands were obtained: unchanged starting material (R_F 0·7; 2 mCi, 28·5%; this was recycled) and methyl 8-formyl[9-^{14}C]-octanoate {[9-^{14}C]-(IV)} (R_F 0·35; 2·7 mCi, 39%, sp. act. 20 mCi mmol^{-1}). Overall yield from [1-^{14}C]elaidate was 25%.

Methyl [9-^{14}C]*crepenynate* {[9-^{14}C]-(1)}. The aldehyde ester {[9-^{14}C]-(IV)} (0·135 mmol, 2·7 mCi) and the Wittig salt (IIA) (0·2 mmol) yielded methyl [9-^{14}C]crepenynate (2·1 mCi; 78%). Overall activity yield from [1-^{14}C]-elaidate by route (*a*) 6·5%, and by route (*b*) 19·5%.

Methyl [9-^{14}C]*linoleate*. Methyl [9-^{14}C]crepenynate {[9-^{14}C]-(I)} (0·272 mCi, sp. act. 20 mCi mmol^{-1}) was converted to methyl [9-^{14}C]linoleate (0·153 mCi, 56%, sp. act. 20 mCi mmol^{-1}) as described for [10-^{3}H]linoleate.

Methyl [9-^{14}C]*oleate*. The aldehyde ester {[9-^{14}C]-(IV)} (0·022 mmol, 1·1 mCi) and the Wittig salt (IIB) (0·032 mmol) yielded methyl [9-^{14}C]oleate (0·517 mCi, 47%, sp. act. 47·6 mCi mmol^{-1}).

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