121. *Synthetic Long-chain Aliphatic Compounds. Part VII.* Some Mono-olefinic Acids.*

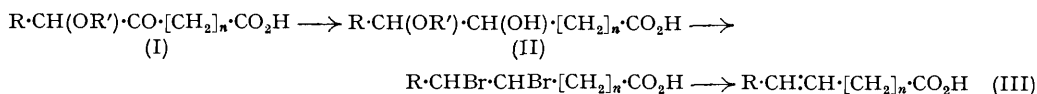By (Miss) B. W. Boughton, R. E. Bowman, and (in part) D. E. Ames.

By the acyloin route (*J.*, 1951, 1079) the pure *cis*- and *trans*-forms of myristoleic, palmitoleic, and gadoleic acids have been obtained. The *cis*- and the *trans*-isomer of octadec-4-enoic acid † have been prepared by the methoxy-ketone route (*loc. cit.*), attempts to use the other route having failed.

In Part III of this series (*J.*, 1951, 1079), we described a method of olefinic acid synthesis, in which acyloins (I; R′ = H) are first reduced to the corresponding dihydroxy-acids which are then separated by fractional crystallisation into the *erythro*- and *threo*-isomers. The

* Part VI, *J.*, 1951, 2752. † Geneva nomenclature ($CO_2H = 1$), throughout.

latter on separate treatment with hydrogen bromide–acetic acid–sulphuric acid, followed by zinc, furnished the individual *cis-* and *trans*-unsaturated acids respectively as follows :

$$R \cdot CH(OR') \cdot CO \cdot [CH_2]_n \cdot CO_2H \longrightarrow R \cdot CH(OR') \cdot CH(OH) \cdot [CH_2]_n \cdot CO_2H \longrightarrow$$
$$(I) \qquad\qquad\qquad\qquad (II)$$

$$R \cdot CHBr \cdot CHBr \cdot [CH_2]_n \cdot CO_2H \longrightarrow R \cdot CH{:}CH \cdot [CH_2]_n \cdot CO_2H \quad (III)$$
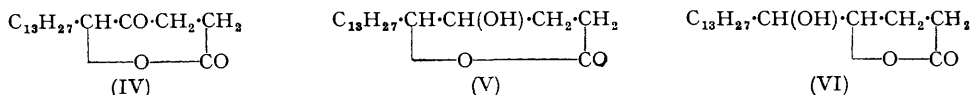
It was considered that *cis-* and *trans*-heptadec-9-enoic acids prepared in this manner were of a high degree of purity and we now report three more examples of this synthesis which, it is thought, provide further evidence of the high purity of unsaturated acids obtained by this method.

First, starting from 2-hydroxyhexanoic acid † and triethyl heptane-1 : 1 : 7-tricarboxylate, we obtained by means of the debenzylation–ketone synthesis (Bowman, *J.*, 1950, 325) the acyloin (I ; $R = CH_3 \cdot [CH_2]_3$, $R' = H$, $n = 7$) which was reduced catalytically; the *erythro-* and *threo*-9 : 10-dihydroxytetradecanoic acids were separated by crystallisation. The separate isomers were then converted into their dibromides which on debromination with zinc furnished *cis-* and *trans*-myristoleic acids (tetradec-9-enoic acids), m. p. −4·5° to −4°, and 18—18·5° respectively. Similarly from 2-hydroxyoctanoic and 2-hydroxydodecanoic acids, *cis-* and *trans*-palmitoleic acids (hexadec-9-enoic acids) of m. p. 0—0·5° and 31—32° respectively, and *cis-* and *trans*-gadoleic acids (eicos-9-enoic acids) m. p. 23—23·5° and 54° respectively, were obtained, all of a high degree of purity as judged by the narrow ranges of their melting points and those of their derivatives and by their excellent iodine values.

Attention was next directed to the synthesis of the octadec-4-enoic acids using the same route. The necessary starting material, 2-hydroxypentadecanoic acid, was obtained by a six-stage synthesis from pure lauryl alcohol and was converted by successive treatment with acetyl and thionyl chlorides into the corresponding acetoxy-chloride which was treated with tribenzyl sodioethane-1 : 1 : 2-tricarboxylate in the usual manner. The yield of product was, however, very low, the crystalline δ-lactone (IV) (*ca.* 12%) and the ethyl ester of (I ; $R = C_{13}H_{27}$, $R' = H$, $n = 2$) (*ca.* 8%) being obtained; the latter could be converted into (IV) by heating it with a catalytic quantity of toluene-*p*-sulphonic acid.

Reduction of (IV) in ethanolic solution using Raney nickel W7 catalyst proceeded readily and yielded one of the isomeric hydroxy-lactones (V) in a pure condition. Evidence for the δ-lactone structure of (V) was obtained by similar reduction of the ethyl ester of a crude specimen of (I ; $R = C_{13}H_{27}$, $R' = H$, $n = 7$) which afforded after hydrolysis and distillation a small quantity of a different crystalline lactone which would undoubtedly be the γ-form (VI) :

$$C_{13}H_{27} \cdot CH \cdot CO \cdot CH_2 \cdot CH_2$$
$$\underset{\text{O}\text{———}\text{CO}}{\rule{0pt}{0pt}}$$
$$(IV)$$

$$C_{13}H_{27} \cdot CH \cdot CH(OH) \cdot CH_2 \cdot CH_2$$
$$\underset{\text{O}\text{———}\text{CO}}{\rule{0pt}{0pt}}$$
$$(V)$$

$$C_{13}H_{27} \cdot CH(OH) \cdot CH \cdot CH_2 \cdot CH_2$$
$$\underset{\text{O}\text{—}\text{CO}}{\rule{0pt}{0pt}}$$
$$(VI)$$

In neither case could the lower-melting isomeric lactone be isolated.

Treatment of (V) with hydrogen bromide–acetic acid–sulphuric acid gave an impure dibromo-acid, converted by zinc under the usual conditions into an olefinic acid, which was obviously a mixture and was obtained in too small a quantity for separation. On account of the low yields obtained with this method and the difficulties associated with later steps, we next investigated our alternative methoxy-ketone route.

The starting material, 2-methoxypentadecanoic acid, was obtained either from the product of interaction of the corresponding bromo-ester with sodium methoxide or by reaction of *n*-tridecyl iodide and sodiomethoxymalonate followed by hydrolysis and decarboxylation in the usual manner. Reaction of this acid and oxalyl chloride gave 2-methoxypentadecanoyl chloride, which on treatment with tribenzyl sodioethane-1 : 1 : 1-tricarboxylate as previously gave, in satisfactory yield, 4-keto-5-methoxyoctadecanoic acid (I ; $R = C_{13}H_{27}$, $R' = CH_3$, $n = 2$), isolated as its methyl ester. Catalytic reduction of the ester over Raney nickel W7 furnished, after hydrolysis and distillation, the methoxy-

† See footnote, p. 671.

lactone (VII) in high yield but conversion of this material into the required 4 : 5-dibromo-acids proved more difficult than usual on account of their tendency to pass into the bromo-lactone (VIII).

$$C_{13}H_{27}\cdot CH(OMe)\cdot CH\cdot CH_2\cdot CH_2 \qquad\qquad C_{13}H_{27}\cdot CHBr\cdot CH\cdot CH_2\cdot CH_2$$

(VII)   O————CO   (VIII)   O————CO

Thus, reaction of (VII) with hydrogen bromide–acetic acid–sulphuric acid furnished a crude semi-solid dibromo-acid (Found : Br, 33. Calc.: Br, 36%) from which a crystalline 4 : 5-dibromo-octadecanoic acid (presumably the *erythro*-form) was isolated by means of its sparing solubility in light petroleum. Our usual practice at this stage has been to convert the acids into their ethyl esters and to percolate the latter through a short column of alumina to remove traces of colour before distillation but, when these techniques were applied to the petroleum-soluble bromo-compounds, the greater part of the product adhered to the absorbent and could not be eluted. Repeated distillation of the eluates eventually gave a semi-solid mass from which one of the diastereoisomers of (VIII) was obtained in an almost pure state : it appears that loss of elements of ethyl bromide took place before absorption on alumina and also afterwards during distillation ; in the former case the alkalinity of the absorbent was sufficient to hold the product as the alkali salt.

Debromination of the solid dibromo-acid with zinc in methanol furnished pure *trans*-octadec-4-enoic acid whereas, after several trials, it was found that a similar debromination of either the bromo-lactone (VIII) or the mixed crude dibromo-acids gave a mixture of the *cis*- and *trans*-acids from which the individual isomers could be obtained by crystallisation of either their zinc salts or, more conveniently, the free acids themselves.

The *cis*-acid had m. p. 40—41°, and the *trans*-acid m. p. 59·5—60·5°, and both acids gave excellent iodine values (Wijs ; 89·4—89·9 ; Calc.: 89·9). Therefore, the acid of m. p. 52° and iodine value of 27·0 (Hübl) obtained by Eckert and Halla (*Monatsh.*, 1913, **34**, 1821) by a series of operations starting from 2-bromostearic acid was presumably a mixture of the αβ- and γδ-unsaturated acids ; our results are in accord with the observations of Linstead and his co-workers (*J.*, 1927, 2565 ; 1929, 2153) that, while αβ- and βγ-unsaturated acids possess iodine values which are either very low or rather high respectively, those of the γδ-isomers approximate to the theoretical values.

EXPERIMENTAL

Unless otherwise specified, the methods of olefinic acid synthesis were as described in Part III (*loc. cit.*) for the *cis*- and *trans*-heptadec-9-enoic acids, the later stages being detailed in Part IV (*J.*, 1950, 1087).

Light petroleum refers to material of b. p. 40—60°.

cis- and trans-*Tetradec*-9-*enoic Acids.*—2-Hydroxyhexanoic acid (m. p. 62—63°) was converted into 2-*acetoxyhexanoyl chloride*, a colourless liquid, b. p. 54°/0·3 mm. (Found : Cl, 18·6. $C_8H_{13}O_3Cl$ requires Cl, 18·4%), and the latter treated with tribenzyl sodio-heptane-1 : 1 : 7-tricarboxylate according to the general method ; the product was hydrogenated, decarboxylated, and esterified, to give *ethyl* 10-*hydroxy*-9-*ketotetradecanoate* as a pale yellow oil, b. p. 144—150°/0·1—0·3 mm., n_D^{20} 1·4596 (Found : C, 67·3 ; H, 9·9. $C_{16}H_{30}O_4$ requires C, 67·1 ; H, 10·5%).

Reduction over Raney nickel W7, followed by hydrolysis, yielded the mixed hydroxy-acids, which were fractionally crystallised from ethanol and then ethanol–ethyl acetate, to give the less soluble erythro- (rhombic plates from ethanol ; m. p. 123—124°) and the more soluble threo-9 : 10-*dihydroxytetradecanoic acid* (prisms from ethyl acetate ; m. p. 80°) (Found : C, 65·1 ; H, 10·8. $C_{14}H_{28}O_4$ requires C, 64·6 ; H, 10·8%).

Reaction of the former dihydroxy-acid with hydrogen bromide–acetic acid–sulphuric acid gave *ethyl* threo-9 : 10-*dibromotetradecanoate*, b. p. 168°/0·5 mm., n_D^{20} 1·4890 (88%) (Found : C, 46·5 ; H, 7·0. $C_{16}H_{30}O_2Br_2$ requires C, 46·4 ; H, 7·3%), converted by zinc into ethyl *cis*-tetradec-9-enoate, b. p. 120°/0·6 mm., n_D^{20} 1·4503 (Found : I.V., 100·0. Calc. for $C_{16}H_{30}O_2$: I.V., 99·8), which on hydrolysis furnished *cis*-tetradec-9-enoic acid, b. p. 144°/0·6 mm., n_D^{20} 1·4563, m. p. (thermometer in liquid) −4·5° to −4° (Found : C, 74·7 ; H, 11·4% ; I.V., 111. Calc. for $C_{14}H_{26}O_2$: C, 74·3 ; H, 11·5% ; I.V., 112). It formed a p-*phenylphenacyl* ester, colourless plates (from light petroleum), m. p. 57—58° (Found : C, 79·5 ; H, 8·4. $C_{28}H_{36}O_3$ requires C, 80·0 ; H, 8·6%).

X X

threo-9 : 10-Dihydroxytetradecanoic acid furnished similarly *ethyl* erythro-9 : 10-*dibromo-tetradecanoate*, b. p. 177°/0·7 mm., n_D^{20} 1·4898 (Found : C, 46·7; H, 7·4%), *ethyl* trans-*tetradec-9-enoate*, b. p. 112°/0·4 mm., n_D^{20} 1·4515 (Found : C, 75·8; H, 11·9%; I.V., 98·9. $C_{16}H_{30}O_2$ requires C, 75·6; H, 11·8%; I.V., 99·8), and finally trans-*tetradec-9-enoic* acid, plates, m. p. 18—18·5°, from light petroleum at −20° (Found : C, 74·8; H, 11·7%; I.V., 112).

cis- and trans-*Hexadec-9-enoic Acids.*—The above synthesis was repeated with 2-*acetoxyoctanoyl chloride*, b. p. 69°/0·3 mm. (Found : Cl, 16·3. $C_{10}H_{17}O_3Cl$ requires Cl, 16·1%), in place of the hexanoic derivative, to give *ethyl* 10-*hydroxy-9-ketohexadecanoate*, a pale yellow oil, b. p. 160—164°/0·4 mm., n_D^{20} 1·4502 (Found : C, 69·2; H, 10·9. $C_{18}H_{34}O_4$ requires C, 68·8; H, 10·9%). Hydrogenation, followed by hydrolysis and fractional crystallisation from ethanol and then ethanol–ethyl acetate, furnished the less soluble *erythro-* (m. p. 129—130°) and the more soluble *threo*-9 : 10-dihydroxyhexadecanoic acid (m. p. 85—86°).

The former acid was then treated with hydrogen bromide in the usual manner, the crude dibromo-acid was esterified and debrominated, and the product hydrolysed and distilled, giving *cis*-hexadec-9-enoic acid as a colourless oil, b. p. 162°/0·6 mm., m. p. 0—0·5°, n_D^{20} 1·4585 (Found : I.V., 100·5. Calc. for $C_{16}H_{30}O_2$: I.V., 100). It formed a p-*phenylphenacyl* ester, plates (from acetone), m. p. 56·5—57° (Found : C, 80·0; H, 8·7. $C_{30}H_{40}O_3$ requires C, 80·4; H, 8·9%). Baudart (*Compt. rend.*, 1945, **220**, 404) reports m. p. 40—41°, a value which is clearly too low by analogy with the derivatives of homologous acids.

The *threo*-dihydroxy-acid gave, in the same manner, *trans*-hexadec-9-enoic acid, colourless plates, m. p. 31—32°, from light petroleum at −30° (Found : I.V., 100·2). Baudart (*loc. cit.*) reports m. p. 32—33°.

cis- and trans-*Eicos-9-enoic Acids.*—The starting materials were 2-*acetoxydodecanoyl chloride*, b. p. 125°/0·7 mm. (Found : Cl, 12·9. $C_{14}H_{25}O_3Cl$ requires Cl, 12·8%), and tribenzyl sodio-heptane-1 : 1 : 7-tricarboxylate. The crude acyloin-acid remaining after removal of unchanged tricarboxylic acid (see Part III ; *loc. cit.*) was esterified azeotropically with ethanol, and the crude ester hydrogenated over Raney nickel in ethanolic solution until absorption of hydrogen ceased. Hydrolysis of the reduction product furnished the mixed dihydroxy-acids which were separated by crystallisation from methanol, to give the less soluble *erythro-* (plates, m. p. 130—131°) and the more soluble *threo*-9 : 10-dihydroxyeicosanoic acids (rectangular plates, m. p. 97—98°).

The former acid then furnished, as before, *ethyl* threo-9 : 10-*dibromoeicosanoate*, b. p. 222°/0·3 mm. (slight decomp.), n_D^{20} 1·4843 (Found : C, 53·7; H, 8·7. $C_{22}H_{42}O_2Br_2$ requires C, 53·0; H, 8·4%), ethyl *cis*-eicos-9-enoate, b. p. 154—155°/0·1 mm., n_D^{20} 1·4545 (Found : I.V., 74·2. Calc. for $C_{22}H_{42}O_2$: I.V., 75·1), and then *cis*-eicos-9-enoic acid, b. p. 170°/0·1 mm., m. p. 23—23·5° (thermometer in liquid) (Found : C, 77·8; H, 12·2%; I.V., 81·3. Calc. for $C_{20}H_{38}O_2$: C, 77·4; H, 12·3%; I.V., 81·8). This formed a lithium salt, which separated from methanol in plates, m. p. 180°, and a p-*phenylphenacyl* ester, colourless glistening plates (from light petroleum), m. p. 66—66·5° (Found : C, 81·1; H, 9·5. $C_{34}H_{48}O_3$ requires C, 81·0; H, 9·5%).

threo-9 : 10-Dihydroxyeicosanoic acid on treatment with the hydrogen bromide reagent furnished erythro-9 : 10-*dibromoeicosanoic acid* as a solid, which crystallised from light petroleum in colourless prisms, m. p. 56° (Found : C, 51·1; H, 8·0. $C_{20}H_{38}O_2Br_2$ requires C, 51·1; H, 8·1%). The latter was esterified azeotropically, the crude ester debrominated with zinc, and the product hydrolysed, to give trans-*eicos-9-enoic acid* as colourless shining plates, m. p. 54°, from methanol (Found : C, 77·5; H, 12·2%; I.V., 80·8. $C_{20}H_{38}O_2$ requires C, 77·4; H, 12·3%; I.V., 81·8). The p-*phenylphenacyl* ester separated as plates, m. p. 75°, from light petroleum (Found : C, 81·0; H, 9·4%).

cis- and trans-*Octadec-4-enoic Acids.*

(I) *Attempts using the Acyloin Route* (with D. E. AMES).—2-*Acetoxypentadecanoyl chloride*. *n*-Dodecylmagnesium bromide (from *n*-dodecanol, f. p. 23·5°) was treated with formaldehyde following Adams and Noller (*Org. Synth.*, 1926, **6**, 22), to give *n*-tridecanol (b. p. 116°/0·6 mm.; f. p. 29·5°; 75%), and the latter converted into the bromide, b. p. 114°/0·8 mm. (Reid, Ruhoff, and Burnett, *ibid.*, 1935, **15**, 24). Reaction with malonic ester in the usual manner, followed by hydrolysis and decarboxylation at 180—200° and then distillation, yielded *n*-pentadecanoic acid, b. p. 165—168°/0·8 mm., f. p. 50°.

The acid was then brominated and the product hydrolysed with aqueous sodium hydroxide as described for the corresponding 2-hydroxynonanoic acid (Part III ; *loc. cit.*), to give 2-hydroxy-pentadecanoic acid (85%), colourless plates (from benzene), m. p. 84°; *ethyl 2-hydroxypenta-decanoate* crystallised from light petroleum at −10° in plates, m. p. 48° (Found : C, 70·2; H, 11·9. $C_{16}H_{32}O_3$ requires C, 70·6; H, 11·9%).

Reaction of the foregoing hydroxy-acid with acetyl chloride as usual, gave 2-*acetoxypenta-decanoic acid*, a sample of which separated from light petroleum at 0° in long needles, m. p. 51—52° (Found : C, 68·4; H, 10·7. $C_{17}H_{32}O_4$ requires C, 68·0; H, 10·7%); the remaining acid was treated with thionyl chloride to give 2-*acetoxypentadecanoyl chloride* as a colourless oil, b. p. 166°/0·6 mm. (80%) (Found : Cl, 10·7. $C_{17}H_{31}O_3Cl$ requires Cl, 11·1%).

5-*Hydroxy*-4-*keto-octadecanoic lactone.* Reaction of the foregoing acid chloride and tribenzyl sodioethane-1 : 1 : 2-tricarboxylate followed by debenzylation, decarboxylation, hydrolysis with aqueous-ethanolic sulphuric acid, and finally esterification with ethanol according to the general procedures yielded an oil which was fractionally distilled, the material of b. p. 180—205°/0·1—0·5 mm. being collected (8 g., 16%); a large residue remained undistilled. Crystallisation of the distillate from light petroleum at − 10° gave a product of m. p. 65—67° (2 g.), a further 4 g. of the same material being obtained similarly from the distillation residue. Combined solids were recrystallised from light petroleum, giving the *keto-lactone* as plates, m. p. 69—69·5° (Found : C, 72·9; H, 10·9. $C_{18}H_{32}O_3$ requires C, 73·0; H, 10·8%).

The mother-liquors from the above crystallisations gave on distillation *ethyl* 5-*hydroxy*-4-*keto-octadecanoate* (4 g.) as a pale yellow oil, b. p. 190°/0·5 mm., n_D^{20} 1·4508 (Found : C, 70·7; H, 11·3. $C_{20}H_{38}O_4$ requires C, 70·1; H, 11·2%).

A sample of the latter (0·5 g.) was recovered apparently unchanged after being heated at 120°/0·5 mm. or at 200°/1 atm. for 1 hour, but in the presence of toluene-*p*-sulphonic acid (10 mg.) under the latter conditions the product solidified on cooling and yielded on crystallisation from light petroleum, the above keto-lactone (0·2 g.), m. p. 69° undepressed on admixture with authentic material.

4 : 5-*Dihydroxyoctadecanoic* 5-*lactone.* Hydrogenation of the foregoing keto-lactone (4 g.) in ethanol over Raney nickel W7 proceeded rapidly and ceased when one mol. of hydrogen had been taken up. The filtered solution was evaporated to dryness under reduced pressure and the residue repeatedly crystallised from light petroleum, to give the *hydroxy-lactone* (1·9 g.) as plates, m. p. 57—58° (Found : C, 72·7; H, 11·1. $C_{18}H_{34}O_3$ requires C, 72·5; H, 11·4%).

Attempts to isolate the other isomer from the filtrates were abandoned after materials of indefinite m. p. were obtained.

4 : 5-*Dihydroxyoctadecanoic* 4-*lactone.* The mother-liquor obtained after separation of the 5-lactone from the distillation residue was refluxed for 3 hours with ethanol (150 c.c.) and concentrated sulphuric acid (1·5 c.c.). After addition of water, the ester was extracted with ethyl acetate–light petroleum (b. p. 60—80°). The combined organic layers were washed with potassium hydrogen carbonate solution and water, dried (MgSO₄), and evaporated. The resulting crude ester was hydrogenated in ethanol, using Raney nickel W7 catalyst, until absorption ceased (1·0 l.). Evaporation of the filtered solution furnished an oil which was refluxed with N-sodium hydroxide (150 c.c.). The acidified solution was extracted with ethyl acetate, the extracts being washed with water and distilled. A pale yellow oil (3·5 g.), b. p. 200—208°/0·5 mm., which partly crystallised when kept, was thus obtained. This material, which presumably contained both isomers of the γ-lactone, was repeatedly recrystallised from light petroleum (b. p. 60—80°), to give slightly impure 4 : 5-*dihydroxy-octadecanoic* 4-*lactone*, clusters of prisms, m. p. 66—68°, depressed to 45—50° by admixture with the isomeric 5-lactone (Found : C, 71·8; H, 11·3. $C_{18}H_{34}O_3$ requires C, 72·5; H, 11·4%).

II. *Synthesis using the Alkoxy-ketone Route.*—2-*Methoxypentadecanoic acid.* (a) *n*-Pentadecanoic acid (80 g.) was brominated with thionyl chloride and bromine (Part III, *loc. cit.*), and the crude bromo-acid chloride treated with methanol and worked up as before. The product was carefully fractionated *in vacuo* through a short Fenske column, fractions of b. p. 151—155°/0·6 mm. having n_D^{20} 1·4606—1·4617 being collected (89%).

The resulting methyl 2-bromopentadecanoate was then added with stirring to a boiling solution of sodium methoxide (from 10 g. of metal) in magnesium-dried methanol (200 ml.), and the mixture was refluxed for 4 hours. Aqueous sodium hydroxide (30 ml. of 10N.) was then added and, after a further 0·5 hour's refluxing, the methanol was removed in steam, and the residue acidified with excess of sulphuric acid, the oily acid being extracted with light petroleum–ethyl acetate (1 : 1). Evaporation of the organic extract furnished almost pure *methoxy-acid*, which was purified by crystallisation from light petroleum (400 ml.) at 0°, whence it separated in colourless plates, m. p. 51—52° (yield, 81—95%) (Found : C, 70·9; H, 11·8. $C_{16}H_{32}O_3$ requires C, 70·6; H, 11·8%).

(b) To a suspension of dry sodium ethoxide (from 16·6 g. of metal; 0·72 mol.) in dry ethyl carbonate (700 ml.), methyl methoxyacetate (75 g., 0·72 mol.) was added and the mixture slowly distilled through a short Fenske column until methanol and ethanol ceased to be evolved and the

temperature of the vapours rose to 123°. *n*-Tridecyl iodide (110 g., 0·36 mol.; b. p. 115°/0·7 mm., n_D^{20} 1·4810) was then added to the refluxing slurry of sodiomethoxymalonic ester, in portions with stirring and, after 5 hours' reaction under reflux, the cooled mixture was poured into excess of dilute sulphuric acid. The neutral products were isolated in the usual manner and distilled, material of b. p. 135—175°/0·5—0·7 mm. (mainly 140°) being collected. The resulting ester was hydrolysed and acidic material isolated and decarboxylated as usual. Distillation afforded 2-methoxypentadecanoic acid (60 g.), b. p. 154°/0·2 mm., f. p. 48°, which was purified with negligible loss by crystallisation from light petroleum, as before.

Methyl 4-keto-5-methoxyoctadecanoate. Attempts to isolate 2-methoxypentadecanoyl chloride from the reaction of the acid with thionyl chloride were unsuccessful on account of persistent foaming and slight decomposition during attempted distillation. The chloride was therefore generated *in situ* with oxalyl chloride and used without isolation as follows. 2-Methoxypentadecanoic acid (54 g., 0·2 mol.) was covered with benzene (AnalaR; 200 ml.), and oxalyl chloride (70 g.) added. After the mixture had been kept overnight at room temperature, all solid had dissolved and the mixture was refluxed for 0·5 hour with little evident further reaction. Excess of oxalyl chloride was then removed by distillation through a short Fenske column until the vapour temperature rose to 80°, more benzene being added when necessary. Finally, all the solvent was distilled off under reduced pressure and the residual chloride in fresh benzene (100 ml.) treated with tribenzyl sodioethane-1 : 1 : 2-tricarboxylate in the usual manner. The product was hydrogenated in ethyl methyl ketone (300 ml.) over palladised strontium carbonate (10 g.; 10% Pd) and then decarboxylated, and the residue esterified with methanol by the Soxhlet method (Part IV, *loc. cit.*). Distillation gave, after a fore-run of starting materials, the *ester* as a colourless liquid, b. p. 165—167°/0·3 mm., n_D^{20} 1·4502 (40 g.) (Found : C, 69·7; H, 11·3. $C_{20}H_{38}O_4$ requires C, 70·2; H, 11·1%).

The free *acid* obtained by hydrolysis separated from light petroleum in plates, m. p. 50·5—51·5° (Found : C, 69·2; H, 10·5. $C_{19}H_{36}O_4$ requires C, 69·5; H, 11·0%).

4-Hydroxy-5-methoxyoctadecanoic 4-lactone (VII). The foregoing ester (34 g.) was hydrogenated in ethanolic solution over Raney nickel W7, and the product hydrolysed and distilled, yielding the *lactone* as a colourless oil (30 g.), b. p. 186°/0·5 mm., n_D^{20} 1·4587 (Found : C, 72·8; H, 11·1. $C_{19}H_{36}O_3$ requires C, 73·1; H, 11·5%). When kept, the product, a mixture of the two isomers, solidified and had f. p. 29—22°.

Reaction of (VII) *with hydrogen bromide.* The lactone (VII) (5 g.) was treated with hydrogen bromide–acetic acid–sulphuric acid according to the general procedure. The reaction product (A) partly solidified (Found : Br, 33·2. $C_{18}H_{34}O_2Br_2$ requires Br, 36·2%) and on crystallisation from light petroleum at 0° furnished erythro-4 : 5-*dibromo-octadecanoic acid* as thin rectangular plates, m. p. 64—64·5° (Found : C, 49·0; H, 7·3. $C_{18}H_{34}O_2Br_2$ requires C, 48·9; H, 7·7%).

The filtrate was evaporated and the residue esterified azeotropically with ethanol. Passage of the resulting crude ethyl ester in light petroleum (200 ml.) through a column (12″) of active alumina, followed by elution with the same solvent (400 ml.) and evaporation of the combined eluates, furnished a pale yellow oil, which distilled as a colourless oil (1·7 g.), b. p. 185°/0·3 mm., n_D^{20} 1·4828. Further elution with acetone and benzene did not yield a significant amount of material.

In a later experiment, in which the chromatographic treatment was not carried out, the product was repeatedly fractionally distilled, giving fractions of b. p. 188—198°/0·4 mm., n_D^{20} 1·4795—1·4858, with no obvious separation. The combined fractions, when kept, however, solidified and, on crystallisation from light petroleum (200 ml.) at −20°, furnished a solid of m. p. 32—33° (clear at 35—36°), which on repeated crystallisation from light petroleum at 0° yielded, in an almost pure condition, one of the stereoisomeric *bromo-lactones* (VIII), m. p. 42° (previous sintering at 38°) (Found : C, 59·8; H, 9·3; Br, 21·5. $C_{18}H_{35}O_2Br$ requires C, 59·8; H, 9·1; Br, 22·2%).

cis-*Octadec-4-enoic acid.* A mixture of zinc dust (7 g.), methanol (75 ml.), and hydrogen bromide (1·5 ml. of 10%) was refluxed for 2 minutes in nitrogen, and the crude bromo-acid (A) (7 g.) in methanol (15 ml.) added. The mixture was refluxed for 5 hours, with hourly additions of fresh zinc (1 g.), and the mixture allowed to cool. The flocculent zinc salts were separated from metallic zinc by flotation and finally by extraction with boiling methanol (yield, 4 g.). By repeated crystallisation from methanol, the less soluble zinc salt of the *trans*-acid, m. p. 123—125°, was obtained pure, but attempts to isolate the zinc salt of the *cis*-acid were not completely successful, a material of m. p. 99—103° being eventually obtained.

Decomposition of the latter (150 mg.) by shaking its ethereal suspension with dilute sulphuric acid, followed by evaporation to dryness, furnished a product still containing some *trans*-acid.

Thus, successive cooling of the product in light petroleum solution to room temperature and $0°$ yielded *trans*-acid (m. p. 58—59° and 56—58°; 12 mg. in all) but at $-30°$ the cis-*acid* was obtained as colourless plates, m. p. 41° (Found : C, 76·6; H, 11·8%; I.V., 89·5. $C_{18}H_{34}O_2$ requires C, 76·6; H, 12·1%; I.V., 89·9). It formed a p-*phenylphenacyl* ester, colourless plates (from acetone), m. p. 65·5—66·5° (Found : C, 80·2; H, 8·8. $C_{32}H_{44}O_3$ requires C, 80·7; H, 9·2%).

An improved procedure consists of decomposing the combined zinc salts, followed by fractional crystallisation of the resulting free acids from light petroleum, as above.

trans-*Octadec*-4-*enoic acid*. Debromination of solid *erythro*-4 : 5-dibromo-octadecanoic acid (1·9 g.) with zinc in methanol, as previously, furnished a sparingly soluble zinc salt, m. p. 123—125°, decomposed to give the pure trans-*acid* (800 mg.), colourless glistening plates (from light petroleum), m. p. 59·5—60·5° (Found : C, 76·1; H, 12·1%). Determinations of the iodine value (Wijs) gave values of 89·3 (0·5 hour) and 89·8 (3 hours) ($C_{18}H_{34}O_2$ requires I.V., 89·9). It formed a p-*phenylphenacyl* ester, which separated from acetone in lustrous plates, m. p. 89° (Found : C, 80·2; H, 9·1%).

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