

BRANCHED-CHAIN FATTY ACIDS. XXVI. SYNTHESIS OF OPTICALLY ACTIVE ACIDS OF USE IN THE STUDY OF THE STRUCTURE OF C<sub>27</sub>-PHTHIENOIC ACID. PARTIAL THERMAL RACEMIZATION OF (-)-5-METHYL-2-TRIDECENOIC ACID<sup>1</sup>

JAMES CASON, NORMAN L. ALLINGER, AND C. FREEMAN ALLEN<sup>2</sup>

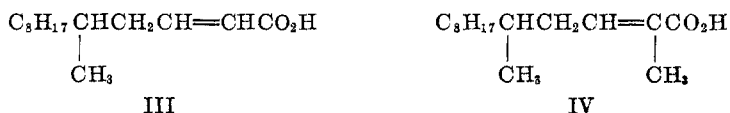
Received January 23, 1953

In a previous paper of this series (1), the strongly dextrorotatory, physiologically active C<sub>27</sub>-phtienoic acid (2), isolated from the tubercle bacillus, was assigned a partial structure which included the features of a 2,5-dimethyl-2-alkenoic acid. Although the position of the double bond and the 2-methyl seemed entirely unequivocal, assignment of the second methyl to the 5-position raised some points of dubiety which have now been further investigated. The assignment to the 5-position (formula I), rather than the 4-position (formula



II), was made because heating of the C<sub>27</sub>-phtienoic acid gave only about 25% racemization, no more than about 5% lactone formation, and no observable equilibration of the double bond with the β, γ-position. Since it has been reported<sup>3</sup> that heating of a 2-alkenoic acid containing a 4-methyl group promotes a high percentage of equilibration of the double bond with the β, γ-position, followed by conversion of much of the acid to the γ-lactone, the behavior of C<sub>27</sub>-phtienoic acid seemed inconsistent with the presence of a 4-methyl group and resulted in assignment of the second methyl to the 5-position. This assignment can be validated, however, only if a 5-methyl-2-alkenoic acid is slowly racemized by thermal equilibration of the α,β-unsaturation with the β,γ- and γ,δ-positions, and if such an acid shows the high molecular rotation (73°) of C<sub>27</sub>-phtienoic acid.

The present investigation has indicated that an α,β-unsaturation may be thermally equilibrated as remotely as the γ,δ-position; however, the asymmetric center in the 5-position results in only a small optical rotation. Neither 5-methyl-2-tridecenoic acid (III) nor 2,5-dimethyl-2-tridecenoic acid (IV) has a molecular



<sup>1</sup> This investigation was supported in part by a research grant from the National Institutes of Health, United States Public Health Service. Parts of this paper were presented before the Division of Organic Chemistry, Buffalo, N. Y., March 25, 1952, and at the Symposium on Fatty Acids and Their Derivatives at the 122nd Meeting of the American Chemical Society, Atlantic City, September 17, 1952.

<sup>2</sup> Previous publications as Charles F. Allen.

<sup>3</sup> Cf. ref. 1 for literature cited in this connection.

rotation<sup>4</sup> which is as much as 5% of that of C<sub>27</sub>-phthienoic acid. A careful re-examination of the published (1, 2) physical and chemical properties of our C<sub>27</sub>-phthienoic acid has failed to reveal a consistency with any structure other than that of a polyalkyl-2-alkenoic acid; hence, the assignment of the second methyl to the 4-position<sup>5</sup> now seems indicated. In order that the properties of an optically active 2,4-dimethyl-2-alkenoic acid may be examined, synthesis of such an acid is being investigated in this laboratory. The behavior of C<sub>27</sub>-phthienoic acid on heating may be reconciled with the 2,4-dimethyl structure if the presence of the 2-methyl group has an unexpectedly large effect in counteracting the tendency of the 4-methyl group to shift the equilibration of the double bond towards the  $\beta, \gamma$ -position.

It is of interest that the original sample of 2-(DL), 5-(L)-dimethyltridecanoic acid, obtained by decarboxylation of the corresponding malonic acid, had a molecular rotation of 2.61°, whereas the same acid obtained by hydrogenation of the (+)-2,5-dimethyl-2-tridecenoic acid (IV) had a molecular rotation of 2.24°. Since the other physical constants of the two samples of this acid are in good agreement, it would appear that there was a very small amount of asymmetric induction in the hydrogenation. Such an effect should be more pronounced if the asymmetric center were at the 4-position, and this may well be responsible for the fact that C<sub>27</sub>-phthienoic acid (2) (dihydro-C<sub>27</sub>-phthienoic acid) has a molecular rotation of about 11.7°; whereas a sample of 4-methyldodecanoic acid, prepared in the present work, has a molecular rotation of only 0.4°.

Our 4-methyldodecanoic acid and 5-methyltridecanoic acid were prepared from L-(-)-3-methylhendecanoic acid (3), but the 4-methyl acid has a molecular rotation of +0.4° and the 5-methyl acid has a molecular rotation of -0.6°. Thus, the 4-methyl acid of the L-series has the larger positive rotation, whereas the opposite relationship has been found by Ställberg-Stenhagen (4) for the 4-methyltetracosanoic and 5-methylpentacosanoic acids. These acids, in the D-series had molecular rotations, respectively, of +1.1° and +0.4°. It follows that even though our terminal *n*-alkyl group was *n*-octyl, a further increase in the size of this group causes a small shift in molecular rotation which, in the case of the 4-methyl acid, involves a change in sign of rotation.

As a part of the present study, a comparison was made of the ultraviolet spectra in 95% ethanol and in hexane. In our previous work, spectra have been determined in ethanol, for it has been reported (5) that saturated acids absorb at a shorter wavelength in non-polar solvents than is the case in ethanol. Since the saturated and  $\alpha, \beta$ -unsaturated acids give maxima near the lower limit of the Beckman spectrophotometer, absorption at the longer wavelength is highly

<sup>4</sup> During the course of this work, we were advised in a private communication from E. Stenhagen that Mrs. Stenhagen had completed the synthesis of another optically active 2,5-dimethyl-2-alkenoic acid and found a similarly small molecular rotation.

<sup>5</sup> Polgar and Robinson [*Chemistry & Industry*, 685 (1951)] have also assigned the second methyl to the 4-position; however, these investigators appear not to have had in hand a sample of acid containing more than about 75% 2-alkenoic acid (cf. ref. 2), and the material used by them for degradation was an extensive mixture of acids. Thus, it would seem hardly proper to regard this evidence as a definitive proof of structure, and their assignment of a name to this acid seems unjustified.

desirable. For the 2-alkenoic acids presently examined by us, however, maxima occur at a slightly *longer* wavelength in hexane, and the bands are sharper than in ethanol; furthermore, hexane does not absorb significantly above 200  $m\mu$ , as does ethanol, and the curves may be extended to 200  $m\mu$  with the Beckman instrument. Representative curves are shown in Fig. 1. The somewhat broader bands at slightly shorter wavelengths, observed in ethanol, may well be due to absorption by 95% ethanol, which sets in slightly below 220  $m\mu$ . Probably for this same reason, somewhat more consistent results are obtained in hexane.

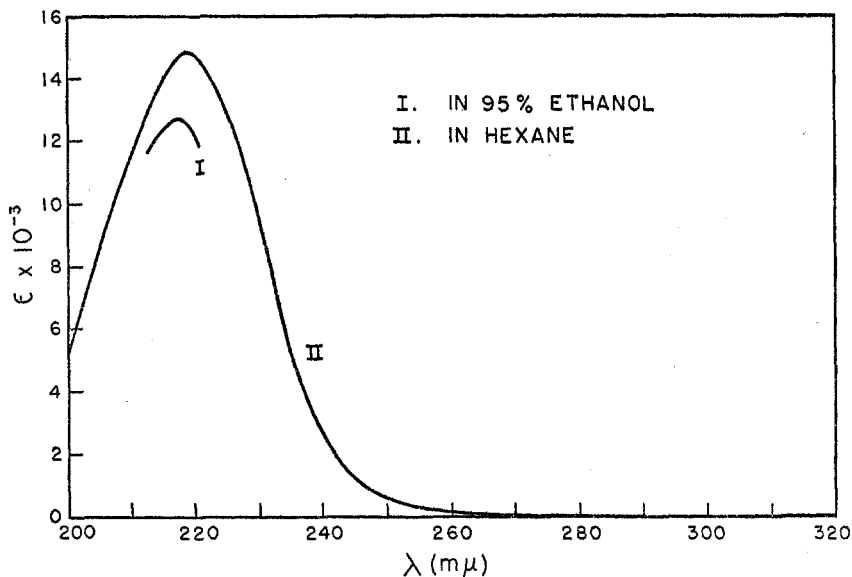


FIG. 1. ULTRAVIOLET ABSORPTION CURVES FOR L-(+)-2,5-DIMETHYL-2-TRIDECENOIC ACID

For a study of thermal racemization of the asymmetric center at the 5-position<sup>7</sup> the presence of the 2-methyl group is undesirable for it would minimize the effect by shifting the position of equilibration of the double bond towards the 2-position. For this purpose, therefore, L-(-)-5-methyl-2-tridecenoic acid was prepared from the corresponding saturated acid by the method previously found (6) most effective for the synthesis of 2-alkenoic acids having no substituent on the double bond. The sample of 2-alkenoic acid obtained by this procedure had a molecular rotation of  $-3.1^\circ$ ,  $\epsilon_{210}$  13,900 (max). After it had been heated for 12 hours at  $220^\circ$  the recovered acid had a molecular rotation of  $+1.7^\circ$ ,  $\epsilon_{210}$  9,300. Since the extinction coefficient for a 3-alkenoic acid<sup>8</sup> is about 1000 at 210

<sup>8</sup> The only accurate absorption data available is that for methyl 3-methyl-3-nonenoate (9), which has an  $\epsilon$  of about 1,600 at 210  $m\mu$ . Since this compound has a methyl substituted at the double bond the curve is shifted to longer wavelengths by 5-10  $m\mu$ ; therefore 1000 is taken as the approximate value at 210  $m\mu$  for the 3-alkenoic acid (or ester) not substituted on the double bond. The accuracy of this figure is adequate for present purposes, for the calculation is not very sensitive to it; if 1,600 be used, the content of 3-enoic acid is raised only to 38%.

$m\mu$  it may be calculated that the pyrolyzed acid contains about 65% 2-enoic acid and 35% 3-enoic acid. It may be further calculated that if no racemization of the asymmetric center occurred on pyrolysis<sup>7</sup> the molecular rotation of the 3-enoic acid is about  $11^\circ$ , that is, about four times the magnitude of, and of opposite sign to, the rotation of the 2-enoic acid. Thus, if racemization on heating is to be measured by a lowering of the rotation of the 2-enoic acid, complete removal of the 3-enoic acid must be assured, and this seems hardly possible.

In order to avoid the difficulties presented by the high positive rotation of the 5-methyl-3-enoic acid, the pyrolyzed acid was hydrogenated, and the rotation of the saturated acid so obtained was compared with that of the original sample of (-)-5-methyltridecanoic acid. The molecular rotation was found to have decreased from  $-0.58^\circ$  to  $-0.44^\circ$ , or by about 25%. The experimental error involved in measuring the optical rotations was no more than  $\pm 4\%$ . The conclusion that about 25% racemization occurred on pyrolysis is valid only if the 3-enoic acid is absent from the recovered saturated acid. Since it is known that a 2-enoic acid hydrogenates much more slowly (2, 7) than a 3-enoic acid and since the mixture of unsaturated acids was about 65% 2-enoic acid, it seems reasonable to assume that the acid obtained after hydrogenation does not contain the 0.9% of 3-enoic acid which may be calculated as required to explain the observed lowering of optical rotation. This assumption has been validated by measurement of the ultraviolet absorption of the recovered hydrogenated acid. The value for  $\epsilon_{210}$  was 139 (max) and  $\epsilon_{205}$  was 124. A pure 5-methylalkanoic acid (8) has  $\epsilon_{209}$  of 53 (max). Since the curve of the hydrogenated acid has a maximum at 210  $m\mu$ , the absorption in excess of 53 must be attributed largely to 2-enoic acid, for the curve for the 3-enoic acid is rising steeply at this wavelength. The maximum content of 2-enoic acid permitted by this absorption would be about 0.6%, which would not contribute an observable rotation. Furthermore, comparison with the absorption spectra of appropriate mixtures has shown that presence of as much as 0.1% of 3-enoic acid in the recovered hydrogenated acid would prevent the absorption from decreasing with wavelength in the region below 210  $m\mu$ .

#### EXPERIMENTAL<sup>8</sup>

*Methyl 2,5-dimethyl-2-heptadecenoate.* For the formation of the 2-bromo-2-methyl ester, there was required some modification of the method previously described (6) for bromina-

<sup>7</sup> Since it is indicated by data cited below that about 25% racemization actually occurred, the best value for the molecular rotation of the 5-methyl-3-enoic acid is about  $12.5^\circ$ .

<sup>8</sup> All melting points are corrected. Except as otherwise specified, all boiling points are uncorrected and distillations were through a 2-ft. column of the simple Podbielniak type (Cason and Rapoport, *Laboratory Text in Organic Chemistry*, Prentice-Hall, Inc., New York, 1950, p. 237). Analyses are by the Microanalytical Division of the Department of Chemistry, Univ. of Calif. Ultraviolet absorption spectra were taken with a Beckman Model DU quartz spectrophotometer in 95% ethanol except where hexane is specified. Concentrations were adjusted to give optical densities in the range of 0.15-1.5. The 1-cm. cells were checked against each other.

tion of acids without 2-substituents. To a mixture of 5.00 g. (16.7 millimoles) of 2,5-dimethylheptadecanoic acid (10) and 4.77 g. (17.4 millimoles, 1.05 molar equiv.) of phosphorus tribromide there was added with stirring 2.81 g. (17.4 millimoles) of dried bromine at such a rate as to keep the exothermic reaction under control. The phosphorus pentabromide dissolved rapidly, then at 85–90° there was added 1.34 g. (8.3 millimoles) of dried bromine. Stirring was continued at this temperature until the bromine color had faded (1 hour), then an additional 1.34-g. portion of bromine was added as stirring and heating were continued. When the bromine color had again faded (2 hours), an additional 1.34-g. portion of bromine was added and stirring at the same temperature continued for an additional 16 hours. To the cooled mixture there was added 4 g. (0.2 mole) of absolute methanol, and after the initial exothermic reaction had subsided the mixture was stirred at 90° for 30 mins. After the cooled two-phase reaction mixture had been shaken out with ether and water, the ether layer was freed of bromine with aqueous sodium sulfite, then washed with water, aqueous bicarbonate, and water, and finally dried with anhydrous sodium sulfate.

The residue remaining after removal of ether from the above-described solution was heated at 150–160° for 3 hours with 10.8 g. (0.084 mole) of distilled technical quinoline. The cooled reaction mixture was shaken with 100 ml. of hexane and 150 ml. of water until most of the tarry quinoline hydrobromide had dissolved, then the hexane was washed alternately with 5% aqueous hydrochloric acid and water until the washings were colorless (insufficient washing leaves some quinoline in the hexane). After the hexane had been further washed with bicarbonate and water, then filtered through anhydrous sodium sulfate, solvent was removed and the residue distilled through a 4-ft. column of the Podbielniak type (11) at 4.4 mm. pressure. Of the seven principal fractions (2.93 g.) collected, the first (b.p. 186.0–186.5°, wt. 0.20 g.) had  $n_D^{25}$  1.4533; and Fracs. 6 and 7 (b.p. 190–191.5°, wt. 1.62 g.) had  $n_D^{25}$  respectively of 1.4577 and 1.4581. In another similar run, the principal fraction had  $n_D^{25}$  1.4577.

The ultraviolet spectrum of Frac. 6, regarded as the purest sample of unsaturated ester, showed absence of dienoic ester or non-conjugated unsaturated ester;  $\epsilon_{204}$  7,600,  $\epsilon_{209}$  10,000,  $\epsilon_{218.5}$  12,100 (max),  $\epsilon_{279}$  69. There was previously reported (10) for a 2-methyl ester  $\epsilon_{212}$  12,200 (max). Hydrogenation in glacial acetic acid with platinum catalyst of a 499-mg. sample of the pure unsaturated ester gave uptake of 34.9 ml. of hydrogen (corrected for catalyst consumption); theory for 1 mole of hydrogen per mole of ester, 35.4 ml. The resultant saturated ester had  $\epsilon_{212}$  100 (max), thus, hydrogenation was complete.

*2,5-Dimethyl-2-heptadecenoic acid* was obtained by saponification of 2.40 g. (from Fracs. 1–7 combined) of the above-described ester. The small amount of saturated acid was removed by partial esterification for 2 hours at 22° with 15 ml. of absolute ethanol containing 0.6 ml. of concentrated sulfuric acid. After countercurrent extraction with the Kies apparatus to remove neutral material and work-up as used previously (10), there was recovered 1.84 g. of acid. For determination of physical constants and analysis, a sample was evaporatively distilled at 170° and 0.1 mm.;  $\epsilon_{212}$  12,200 (max, in ethanol),  $\epsilon_{218.5}$  12,700 (max, in hexane),  $n_D^{25}$  1.4662, equiv. wt. 296.0 (calc'd for  $C_{19}H_{36}O_2$ , 296.5).

*Diethyl (+)-5-methyltridecane-2,2-dicarboxylate. (+)-1-Bromo-3-methylhendecane* was prepared in an optically pure condition by the multi-step process previously reported (3), b.p. 118–118.5° (5.5 mm.),  $[\alpha]_D^{25}$  +5.01°. The previously reported value was  $[\alpha]_D^{25}$  +5.17°. Alkylation of diethyl methylmalonate with this bromide gave an 84% yield of the substituted malonic ester, b.p. 186–187° (4.5 mm.),  $n_D^{25}$  1.4398,  $\alpha_D^{21}$  +1.36° (homogeneous).

*Anal.* Calc'd for  $C_{20}H_{38}O_4$ : C, 70.13; H, 11.19.

Found: C, 70.59; H, 11.24.

*(+)-2-(DL),5-(L)-Dimethyltridecanoic acid.* Saponification and decarboxylation of the above malonic ester gave 93.5% yield of the monocarboxylic acid, b.p. 176–177.5° (5.5 mm.),

<sup>9</sup> Higher temperatures must be avoided, else some dehydrobromination occurs during the period of bromination, and this leads eventually to dienoic acid in the final product (*Cf.* ref. 10).

$n_D^{25}$  1.4439,  $d_4^{27}$  0.8812,  $\alpha_D^{27} + 0.949^\circ$  (homogeneous),  $[\alpha]_D^{27} + 1.08^\circ$ ,  $[M]_D^{27} + 2.61^\circ$ ,  $\lambda_{\max}$  211  $m\mu$ ,  $\epsilon$  81;  $\epsilon_{205}$  70 (clearly defined maximum).

Anal. Calc'd for  $C_{15}H_{30}O_2$ : Equiv. wt., 242.4. Found: Equiv. wt., 242.0.

The *p*-bromoanilide, prepared by a procedure previously described (12), after three crystallizations from ethanol, formed tiny needles, m.p. 123.8–124.8°. The solubility in acetone or chloroform was too low to permit determination of the small optical rotation.

Anal. Calc'd for  $C_{21}H_{34}BrNO$ : N, 3.58. Found: N, 3.46.

Methyl (+)-2,5-dimethyl-2-tridecenoate was prepared from 7.00 g. of the corresponding saturated acid by the procedure described above for methyl 2,5-dimethyl-2-heptadecenoate. Initial distillation of the unsaturated ester from a Claisen flask yielded 5.94 g. (81%), b.p. 140–146° (3.5 mm.). Fractionation through the 4-ft. column (11) yielded seven principal fractions of which the first weighed 0.548 g., b.p. 143–146° (4.5 mm.),  $n_D^{25}$  1.4522. Fractions 4–6 weighed 3.483 g. (47.5%), b.p. 148° (4.5 mm.),  $n_D^{25}$  respectively 1.4545, 1.4551, 1.4551. For Frac. 5, regarded as the purest sample,  $\lambda_{\max}$  218.5  $m\mu$ ,  $\epsilon$  12,380,  $\alpha_D^{25} + 0.30^\circ$  (c, 0.353 g./ml., chloroform),  $[\alpha]_D^{25} + 0.85^\circ$ .

Anal. Calc'd for  $C_{16}H_{30}O_2$ : C, 75.53; H, 11.89.

Found: C, 75.46; H, 11.90.

(+)-2,5-Dimethyl-2-tridecenoic acid was obtained from 3.20 g. of Fracs. 3–6 of the ester, by saponification, partial esterification, and further work-up as described under the 2,5-dimethyl-2-heptadecenoic acid. The final product was distilled rapidly (10 mins.) from a Claisen flask, and collected in four fractions, b.p. 182° (3 mm.),  $n_D^{25}$  respectively 1.4665, 1.4663, 1.4663, 1.4665. Fraction 2 was used for analytical data;  $\epsilon_{217.5}$  12,700 (max, in ethanol),  $\epsilon_{218.5}$  14,870 (max, in hexane),  $\alpha_D^{27} + 0.239^\circ$  (c, 0.2695 g./ml., chloroform),  $[\alpha]_D^{27} + 0.925^\circ$ ,  $[M]_D^{27} + 2.22^\circ$ , equiv. wt. 237.4 (calc'd for  $C_{15}H_{28}O_2$ , 240.4).

A 418-mg. sample of Frac. 3 was hydrogenated in glacial acetic acid with platinum catalyst. Reduction was complete in 40 mins. (no further absorption in 10 hours), and hydrogen uptake (corrected for catalyst absorption) was 44.8 ml. (calc'd, 42.9 ml.). After dilution of the reduction mixture with water the acid was extracted with benzene and distilled in a Claisen flask, b.p. 149–154° (1 mm.),  $n_D^{25}$  1.4435,  $\epsilon_{210}$  95 (in hexane),  $\alpha_D^{27} + 0.824^\circ$  (homogeneous),  $[\alpha]_D^{27} + 0.935^\circ$ ,  $[M]_D^{27} + 2.24^\circ$ .

(+)-4-Methyl-dodecanoic acid was prepared from (+)-1-bromo-3-methylundecane (3) via the nitrile procedure of Ruhoff (13) except that the acid was freed from neutral material by use of counter-current extraction with alkali (10) and directly fractionated, b.p. 162–164° (5.5 mm.),  $n_D^{25}$  1.4424,  $\alpha_D^{25} + 0.175^\circ$  (homogeneous),  $[\alpha]_D^{25} + 0.20^\circ$  ( $d^{25}$  estimated as 0.888),  $[M]_D^{25} + 0.42^\circ$ .

Anal. Calc'd for  $C_{13}H_{26}O_2$ : Equiv. wt., 214.4. Found: Equiv. wt., 216.

Diethyl (+)-4-methyl-dodecane-1,1-dicarboxylate was prepared in 88% yield by alkylation of diethyl malonate with (+)-1-bromo-3-methylundecane (3); b.p. 172–173.5° (4 mm.),  $n_D^{25}$  1.4378,  $\alpha_D^{20} + 2.04^\circ$  (homogeneous).

Anal. Calc'd for  $C_{19}H_{38}O_4$ : C, 69.90; H, 10.50.

Found: C, 69.23; H, 10.59.

(-)-5-Methyltridecanoic acid was prepared in 73% yield by hydrolysis and decarboxylation of the above substituted malonic ester; b.p. 172–172.5° (5.5 mm.),  $n_D^{25}$  1.4437,  $d^{25}$  0.886,  $\alpha_D^{25} - 0.224^\circ$  (homogeneous),  $[\alpha]_D^{25} - 0.252^\circ$ ,  $[M]_D^{25} - 0.58^\circ$ .

Anal. Calc'd for  $C_{14}H_{28}O_2$ : Equiv. wt., 228.4. Found: Equiv. wt., 232.

The *p*-bromoanilide, prepared as before (12), after three crystallizations from ethanol, formed small waxy crystals, m.p. 89.5–92°, but melted completely when placed in a bath pre-heated to 89° (presumably polymorphic),  $[\alpha]_D^{25} - 0.25^\circ$  (c, 0.148 g./ml., carbon tetrachloride).

Anal. Calc'd for  $C_{20}H_{32}BrNO$ : N, 3.64. Found: N, 3.39.

(-)-5-Methyl-2-tridecenoic acid was prepared from 17 g. of the saturated acid by bromination and dehydrohalogenation with potassium *tert*-butoxide according to the procedure previously described (6) for synthesis of 5-methyl-2-hendecenoic acid, except that the product was fractionally distilled prior to purification by partial esterification. After 1.1

g. of fore-run, there was obtained as principal fraction 3.74 g. of b.p. 156–158° (1.5 mm.),  $n_D^{25}$  1.4615. Although this fraction was a nearly pure sample of unsaturated acid, it was partially esterified by the usual procedure (6) for 3 hours at 20°, separated by counter-current extraction with alkali, and rapidly distilled in a Claisen flask; wt., 2.79 g., b.p. 168–170° (2.5 mm.),  $n_D^{25}$  1.4620,  $d_4^{25}$  0.908,  $\alpha_D^{25}$   $-1.244^\circ$  (homogeneous),  $[\alpha]_D^{25}$   $-1.370^\circ$ ,  $[M]_D^{25}$   $-3.10^\circ$ ,  $\epsilon_{210}$  13,900 (max),  $\epsilon_{205}$  13,000.

*Anal.* Calc'd for  $C_{14}H_{26}O_2$ : Equiv. wt., 226.4. Found: Equiv. wt., 230.

*Pyrolysis of (-)-5-methyl-2-tridecenoic acid.* A 1.0-g. sample of the unsaturated acid was heated in a sealed tube at 220° for 12 hours. Neutral material was removed from the acid by use of Amberlite IRA-400 strong anion exchange resin (14), and the acid was rapidly distilled in a Claisen flask to yield 0.52 g.,  $n_D^{25}$  1.4585,  $\alpha_D^{25}$   $+0.702^\circ$  (homogeneous),  $[M]_D^{25}$   $+1.74^\circ$  (density of the 2-enoic acid used),  $\epsilon_{210}$  9,300. This acid was hydrogenated in 10 ml. of glacial acetic acid, using 0.1 g. of commercial platinum oxide catalyst, and the hydrogenation was allowed to continue for 12 hours. The recovered acid, after rapid distillation in a Claisen flask, had  $\epsilon_{210}$  139,  $\epsilon_{205}$  124,  $\alpha_D^{25}$   $-0.170^\circ$  (homogeneous),  $[M]_D^{25}$   $-0.44^\circ$ , Equiv. wt., 238,  $n_D^{25}$  1.4439.

#### SUMMARY

There is described an efficient method for converting 2-alkylalkanoic acids to the corresponding 2-alkyl-2-alkenoic acids. The method is applicable to acids having additional substituents on the chain, and it has been applied to synthesis of 2,5-dimethyl-2-heptadecenoic acid and L-(+)-2,5-dimethyl-2-tridecenoic acid. The low molecular rotation of the latter acid makes untenable the assignment of the second methyl in  $C_{27}$ -phthienoic acid to the 5-position.

There is also described the synthesis and partial thermal racemization of L-(-)-5-methyl-2-tridecenoic acid.

BERKELEY 4, CALIF.

#### REFERENCES

- (1) CASON, FREEMAN, AND SUMRELL, *J. Biol. Chem.*, **192**, 415 (1951).
- (2) CASON AND SUMRELL, *J. Biol. Chem.*, **192**, 405 (1951).
- (3) PROUT, CASON, AND INGERSOLL, *J. Am. Chem. Soc.*, **70**, 298 (1948).
- (4) STÄLLBERG-STENHAGEN, *Arkiv Kemi*, **3**, 117 (1951).
- (5) RUSOFF, PLATT, KLEVENS, AND BURR, *J. Am. Chem. Soc.*, **67**, 673 (1945).
- (6) CASON, ALLINGER, AND SUMRELL, *J. Org. Chem.*, preceding paper.
- (7) DUNWORTH AND NORD, *J. Am. Chem. Soc.*, **74**, 1457 (1952).
- (8) CASON AND SUMRELL, *J. Org. Chem.*, **16**, 1177 (1951).
- (9) CASON AND SUMRELL, *J. Org. Chem.*, **16**, 1181 (1951).
- (10) CASON, ALLINGER, AND WILLIAMS, *J. Org. Chem.*, 2nd paper preceding.
- (11) CASON, ALLINGER, SUMRELL, AND WILLIAMS, *J. Org. Chem.* **16**, 1172 (1951).
- (12) CASON, *J. Org. Chem.*, **13**, 236 (1948).
- (13) RUHOFF, *Org. Syntheses*, Coll. Vol. II, 292 (1943).
- (14) CASON, SUMRELL, AND MITCHELL, *J. Org. Chem.*, **15**, 856 (1950).