group and a N=C double bond.[8] To the best of our knowledge, an analogous activation by a carbonyl group has not been observed before;[9] indeed, on the whole, experience has shown that in such cases fluorine is *the most easily replaceable substituent.*

3-Chlorophthalic anhydride did not react with potassium cyanide under the same operating conditions.

EXPERIMENTAL

3-Chlorophthalic anhydride was prepared according to Newman and Scheurer[2] from 3-nitrophthalic anhydride[10] and gaseous chlorine. The temperature of the bath was kept exactly at 250°, the liquid product poured into a mortar and, after it solidified, ground to a fine powder. It was not necessary to distill it; already in its crude stage it melted at 118–124° and after trituration with anhydrous ether at 125–127°. The yield was 76%.

3-Fluorophthalic anhydride. In a Claisen flask (for distillation of solid compounds) of 100-ml. capacity, 20 g. of anhydrous potassium fluoride[11] was covered with a layer of 20 g. of 3-chlorophthalic anhydride and the mixture heated at 280–290° for 45 min. Distillation at 220–225°, 80 mm. gave a clean fraction (11 g.), which solidified spontaneously and was recrystallized from 75 ml. of toluene, m.p. 160°; yield, 9 g. (50%).

Anal. Calcd. for $C_8H_3FO_3$: C, 57.8; H, 1.8; F, 11.4. Found: C, 58.1; H, 2.1; F, 11.0.

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(7) G. C. Finger and C. W. Kruse, *J. Am. Chem. Soc.*, **78**, 6034 (1956). See also J. F. Bunnett and R. E. Zahler, *Chem. Revs.*, **49**, 273 (1951).

(8) G. C. Finger and L. D. Starr, *J. Am. Chem. Soc.*, **81**, 2674 (1959).

(9) One may recall the easy replacement of sulfonic acid groups by molecular chlorine in the α-positions of the anthraquinone system. See, *e.g.*, V. V. Kozlov, *J. Gen. Chem.* (*U.S.S.R.*), **17**, 289 (1947); *Chem. Abstr.*, **42**, 550 (1948).

(10) *Org. Syntheses*, **Coll. Vol. I**, 408 (1941).

(11) Analytical grade (Messrs. Baker and Adamson, anhydrous, granulated) was used. It is necessary that the *p*H of an aqueous solution be about 8.0.

Unsymmetrical Quaternary Carbon Compounds. III. The Preparation and Resolution of Aliphatic Trialkylacetic Acids[1,2]

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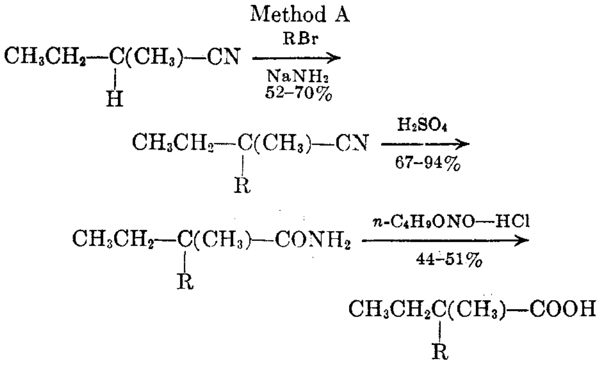
Trialkylacetic acids have been prepared by at least six different methods.[3–9] However, only the two procedures indicated by methods A and B seemed to afford convenient, general routes for the preparation of unsymmetrical, racemic trialkylacetic acids. Method A was derived from work of Sperber, Papa, and Schwenk[4,10] and method B was modified from the report of Hudson and Hauser.[5]

For method A, 2-methylbutanenitrile was prepared by the monoalkylation of propanenitrile with ethyl bromide in the presence of sodium amide,[3,4,10] a process which furnished only 30–36% of monoalkylation product and 12% of the dialkylation product, 2-ethyl-2-methylbutanenitrile. Better yields would have resulted from dehydration of the 2-methylbutanamide.[11]



Method A

$$\mathrm{CH_3CH_2{-}\underset{\underset{\displaystyle H}{|}}{C}(CH_3){-}CN} \xrightarrow[\substack{\mathrm{NaNH_2}\\ 52\text{–}70\%}]{\mathrm{RBr}} \mathrm{CH_3CH_2{-}\underset{\underset{\displaystyle R}{|}}{C}(CH_3){-}CN} \xrightarrow[67\text{–}94\%]{\mathrm{H_2SO_4}} \mathrm{CH_3CH_2{-}\underset{\underset{\displaystyle R}{|}}{C}(CH_3){-}CONH_2} \xrightarrow[44\text{–}51\%]{n\text{-}\mathrm{C_4H_9ONO{-}HCl}} \mathrm{CH_3CH_2\underset{\underset{\displaystyle R}{|}}{C}(CH_3){-}COOH}$$

R = n-C_3H_7, n-C_4H_9, n-C_5H_{11}, n-C_6H_{13}.

The second alkylation with *n*-propyl, *n*-butyl, *n*-amyl, and *n*-hexyl bromides was more efficiently performed (52–70% yields). Hydrolysis of these nitriles in sulfuric acid[4] gave 67–94% yields of the amides. However, conversion of the amides to the corresponding acids with butyl nitrite and hydrochloric acid furnished poor yields (44–51%) of acids; for these acids contained the butyl ester, presumably because of water contamination in the reactants.

Method B essentially followed the procedure of Hudson and Hauser[5] substituting sodium hydride

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(1) Paper II of this series was F. S. Prout, E. P.-Y. Huang, R. J. Hartman, and C. J. Korpics, *J. Am. Chem. Soc.*, **76**, 1911 (1954).

(2) Abstracted from the Masters Theses of Bohdan Burachinsky (1959) and Herbert L. Young (1953) and the Senior Thesis of William T. Brannen, Jr. (1958).

(3) K. Ziegler and H. Ohlinger, *Ann.*, **495**, 84 (1932).

(4) N. Sperber, D. Papa, and E. Schwenk, *J. Am. Chem. Soc.*, **70**, 3091 (1948).

(5) B. E. Hudson, Jr. and C. R. Hauser, *J. Am. Chem. Soc.*, **62**, 2457 (1940).

(6) C. L. Carter and S. N. Slater, *J. Chem. Soc.*, 130 (1946).

(7) W. v. E. Doering and K. B. Wiberg, *J. Am. Chem. Soc.*, **72**, 2608 (1950).

(8) S. Ställberg-Stenhagen, *Arkiv. Kemi*, **3**, 273 (1951).

(9) A. Haller and E. Bauer, *Compt. rend.*, **148**, 127 (1909); J. G. Aston, J. T. Clarke, K. A. Burgess, and R. B. Greenburg, *J. Am. Chem. Soc.*, **64**, 300 (1942); A. A. Sacks and J. G. Aston, *J. Am. Chem. Soc.*, **73**, 3902 (1951); C. T. Lester and J. R. Proffitt, Jr., *J. Am. Chem. Soc.*, **71**, 1877 (1949); C. Schuerch, Jr., and E. H. Huntress, *J. Am. Chem. Soc.*, **70**, 2824 (1948); J. Cason, *J. Org. Chem.*, **13**, 227 (1948); A review is given by A. C. Cope, H. L. Holmes, and H. O. House, *Organic Reactions*, IX, 107–331 (1957).

(10) *Cf.* also G. L. Goerner and A. A. Holzschuh, *J. Org. Chem.*, **23**, 1346 (1958).

(11) C. L. Stevens and T. H. Coffield, *J. Am. Chem. Soc.*, **73**, 103 (1951).

TABLE I

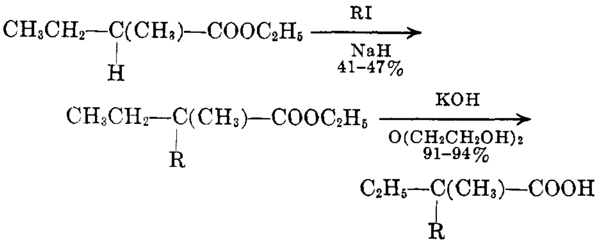
t-ALKYLCARBONITRILES, $R(C_2H_5)(CH_3)C—CN$

R	Yield, %	B.P. °C., (mm. Hg)	n_D^{25}	d^{25}	% Nitrogen Calcd.	% Nitrogen Found
C_2H_5	12[a]	153–154 (744)	1.4072	0.8034	12.60	12.36
n-C_3H_7	52[b]	172–173 (748)	1.4138	0.8062	11.19	10.93
n-C_4H_9	70[c]	94–95 (27)	1.4196	0.8095	10.06	9.78
n-C_5H_{11}	68[c]	120–121 (44–47)	1.4237	0.8123	9.14	9.01
n-C_6H_{13}	66[c]	114–115 (15–16)	1.4274	0.8147	8.37	8.21

[a] This product was a by-product from the monoalkylation of propanenitrile. [b] In this run 0.3 mole of 2-methylbutanenitrile, 0.375 mole of bromide, and 0.3 mole of sodium amide were used. [c] In these runs 0.5 mole of 2-methylbutanenitrile, 0.625 mole of alkyl bromide, and 0.5 mole of sodium amide were used.

for triphenylmethylsodium as the alkylating agent. The alkylation yields (41–47%) with normal iodides were lower than the 59% yield reported for the preparation of ethyl 2-ethyl-2-methylpentanoate.[5] However, the availability of sodium hydride and the ease of operation makes this the preferred procedure. Hydrolysis of the esters was essentially quantitative.

Method B



$$CH_3CH_2—\underset{\displaystyle H}{\underset{|}{C}}(CH_3)—COOC_2H_5 \xrightarrow[\substack{NaH\\41–47\%}]{RI} CH_3CH_2—\underset{\displaystyle R}{\underset{|}{C}}(CH_3)—COOC_2H_5 \xrightarrow[\substack{O(CH_2CH_2OH)_2\\91–94\%}]{KOH} C_2H_5—\underset{\displaystyle R}{\underset{|}{C}}(CH_3)—COOH$$

$R = n$-C_3H_7, n-C_4H_9, n-C_5H_{11}.

The partial resolution of three of these acids was effected by extensive crystallization of their brucine salts. The specific rotations ($[\alpha]_D^{25}$) of these acids were low: +1.05°, +1.23° and +2.34° for 2-ethyl-2-methylpentanoic, 2-ethyl-2-methylhexanoic and 2-ethyl-2-methylheptanoic acids, respectively.[12] The homologous acids reported in the literature have recorded higher rotations: 2-ethyl-2-methyleicosanoic acid, $[\alpha]_D^{23}$ −4.28°[8] and 2-ethyl-2,4-dimethylpentanoic acid, $[\alpha]_D^{24}$ +21.55°.[7]

EXPERIMENTAL

The starting alkyl bromides and iodides, 2-methylalkanoic acids and propanenitrile were obtained commercially. Their boiling points agreed with literature values. Ethyl 2-methylbutanoate, ethyl 2-methylpentanoate, and ethyl 2-ethylhexanoate were prepared in 88%, 82.5%, and 89% yields from the acids by the benzene method of Pinkney.[13] Sodium and ammonia used for the preparation of sodium amide[14] were reagent grade. Fifty percent of sodium hydride emulsion in mineral oil supplied by Metal Hydrides, Inc., or by Callery Chemicals was usually used as alkylating agent; but crystalline sodium hydride (Metal Hydrides) was used in some instances. Dioxane was purified by the method of Fieser[15] or merely by distilling the dioxane from sodium.

All boiling points and melting points were uncorrected. Densities were taken in absolute units (g./cc.). Elemental analyses were performed by Micro-Tech Laboratories, Skokie, Illinois, and Drs. Weiler and Strauss, Oxford, England. Rotations were observed in a Rudolph Polarimeter with a Lippich double field polarizer. All final distillations were effected in a 60-cm., heated Vigreux column with no head (V-1), in a 40-cm., helix-packed column equipped with a total reflux, partial take-off head (V-2) or in a 25-cm., unheated helix-packed column with no head (V-3).

2-Methylbutanenitrile was prepared in 30–36% yields by the reaction of 2.0 moles of propanenitrile with 3.0 moles of ethyl bromide in boiling ether with a suspension of 2.0 moles of sodium amide.[14] (This method was essentially that described below for 2-ethyl-2-methylpentanenitrile.) The purified product had a boiling point of 124–126° (746 mm.), n_D^{25} 1.3875. The literature[11] reports b.p. 123–125°, n_D^{25} 1.3885. The yield was reduced by using an equivalent amount of bromide (14%), by using a lower temperature of 10–20° (25%), or by changing the solvent to benzene (12%).

Accompanying the desired product in 12% yield was the higher-boiling dialkylation product *2-ethyl-2-methylbutanenitrile* (see Table I).

A similar procedure using sodium hydride and butyl bromide has been reported.[10] However, this nitrile would have been prepared more efficiently by dehydration of the amide.[11]

2-Methylbutanamide prepared[4] from the nitrile melted at 109–111°. Newbold and Spring[16] reported a melting point 111–112°.

2-Ethyl-2-methylbutanamide was prepared[4] in 74% yield: m.p. 75.5–78.5° (reported,[17] m.p. 78–79°).

2-Ethyl-2-methylpentanenitrile. This alkylation was run under a nitrogen atmosphere in a three-necked flask equipped with a stirrer, condenser, and a dropping funnel also fitted with a stirrer. Sodium amide, prepared from 8 g. of sodium and about 200 ml. of anhydrous ammonia,[14] was suspended in 100 ml. of toluene and was placed in the dropping funnel. A solution of 25.5 g. of 2-methylbutanenitrile, 46.1 g. of n-propyl bromide, and 50 ml. of toluene was placed in the flask and the black amide suspension was added in 90 min. while the reaction mixture was heated gently under reflux. Reflux of the stirred mixture was continued for 2 hr. by which time the mixture had turned gray. (The time of reaction was established by measurement of the ammonia evolved during reaction.)

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(12) 2-Ethyl-2-methyleicosanoic acid has a molecular rotation of −15.2° (ref. 8 gives $[\alpha]_D^{23}$ −4.28°). Thus, assuming that homologues have nearly the same molecular rotation, the estimated specific rotations for the three acids resolved in this work would be 10.5°, 9.6°, and 8.8°.

(13) P. S. Pinkney, *Org. Syntheses*, **Coll. Vol. II**, 265 (1943).

(14) M. T. Leffler, *Organic Reactions*, I, 99 (1942).

(15) L. F. Fieser, *Experiments in Organic Chemistry*, 3rd Ed., D. C. Heath and Co., New York, N. Y. (1957) p. 285.

(16) G. T. Newbold and F. S. Spring, *J. Chem. Soc.*, 373 (1947).

(17) A. Haller and E. Bauer, *Compt. rend.*, **148**, 130 (1909).

The reaction mixture was filtered to remove the solids and the solution was distilled (V-2). After removal of the solvent and forerun (b.p. 93–170°) the product was obtained: b.p. 170–173°; 19.5 g. (52%); n_D^{25} 1.4138–1.4140.

When ether or benzene were solvents, the yields were reduced to 0% or 35%, respectively. Addition of the sodium amide in 30 min. reduced the yield to 44%.

Repetition of this procedure using *n*-butyl bromide, *n*-amyl bromide and *n*-hexyl bromide gave 70%, 68%, and 66% yields of trialkylacetonitriles. The properties of the purified products are summarized in Table 1.

2-Ethyl-2-methylpentanamide. A mixture of 25.0 g. of 2-ethyl-2-methylpentanenitrile and 300 g. of 80% (by weight) sulfuric acid was heated and stirred at 85–95° for 12 hr.[4] The brownish reaction mixture was poured into ice and extracted three times with benzene. After washing the extracts with sodium carbonate solution and drying with magnesium sulfate, the solvent was removed and the product was distilled under reduced pressure: b.p. 91–116° (1 mm.); 19.2 g. (67%).

A somewhat lower yield (56%) resulted when 80% (by volume) sulfuric acid was used. The results of the other nitrile hydrolyses run essentially in the same way are assembled in Table II.

TABLE II

AMIDES, $R(C_2H_5)(CH_3)C{-}CONH_2$, FROM HYDROLYSIS OF *t*-ALKYLCARBONITRILES

R—	Boiling Point		Yield, %	% Nitrogen	
	Observed °C., (mm. Hg)	Literature[a] °C., (mm. Hg)		Calcd.	Found
C_2H_5—	142–144 (19)[b]		74[c]		
n-C_3H_7—	105–112 (1)[d]	134–135 (12)	67		
n-C_4H_9—	122–132 (1)	124–144 (18)	84	8.91	8.62
n-C_5H_{11}—	127–128 (1)	147–153 (19)	90	8.18	7.96
n-C_6H_{13}—	143–148 (1)	152–162 (18)	94	7.56	7.18

[a] Results of Carter and Slater (ref. 6). [b] The melting point was 75.5–78.5° (lit.,[17] 78–79°). [c] This amide was extracted from the hydrolysis mixture with nine portions of chloroform. [d] Purified from the product described in the Experimental and having m.p. 40–41° (reference 5 gives m.p. 42–43°).

Ethyl 2-ethyl-2-methylpentanoate. A three-necked flask was fitted with a stirrer, a condenser and a thermometer and was arranged for a nitrogen atmosphere. After careful drying 45.5 g. of ethyl 2-methylbutanoate, 100 g., of *n*-propyl iodide, 25 g. of 50% sodium hydride emulsion (Callery Chemicals), and 100 ml. of purified dioxane[15] (or dioxane distilled only from sodium) were quickly added to the flask. This mixture was heated under gentle reflux for 8 hr. (Heating was adjusted so that about 1.25 l. of hydrogen per hour was evolved. Passing the evolved gases through a Dry Ice-acetone trap demonstrated that some *n*-propyl iodide was entrained.)

After the reflux had been completed 100 ml. of 95% ethanol was carefully added to destroy the excess sodium hydride. When hydrogen evolution had ceased 600 ml. of water was cautiously added. After the two clear phases were formed, the mixture was extracted with two portions of benzene. The organic extracts were washed with water and saturated sodium chloride solution, were dried by filtering through sodium sulfate, and were distilled (V-3). The fractions boiling from 120–260° were redistilled (V-2) to give 25.5–28 g. (42–47%) of product: b.p. 180–185°, n_D^{25} 1.4125.

When an approximately equal amount of iodide (0.39 mole) was used, the yields were 31–32.5%. The use of sodium hydride emulsion from Metal Hydrides reduced the yield (from 31% to 18% and from 44% to 33%). The use of toluene as solvent reduced yields 10–18% when propyl iodide was used. The substitution of *n*-propyl bromide for the iodide with toluene as solvent gave a 31% yield (*cf.* 26% using the iodide in toluene and 44% using iodide in dioxane). However, the use of a 200% excess of the *n*-propyl bromide in toluene gave a 41% yield. An old sample of crystalline sodium hydride gave poor yields (22–30%) of ester. Attempted alkylation with isopropyl iodide failed entirely.

This ester was also prepared in 53.5% yield by the action of ethyl iodide on ethyl 2-methylpentanoate. The reaction of *n*-butyl iodide and *n*-amyl iodide with ethyl 2-methylbutanoate produced *ethyl 2-ethyl-2-methylhexanoate* (41.2%) and *ethyl 2-ethyl-2-methylheptanoate* (45.0%), respectively. However, because of halide loss and low reaction temperature the alkylation of ethyl 2-ethylhexanoate with methyl iodide gave only an 8.2% yield of ethyl 2-ethyl-2-methylhexanoate. The results of all these runs are summarized in Table III.

Hydrolysis of amides. 2-Ethyl-2-methyloctanoic acid. As an example of amide hydrolysis,[4] a mixture of 48.7 g. of 2-ethyl-2-methyloctanamide in 300 ml. of dry dioxane was saturated with gaseous hydrochloric acid. Then 54 g. of *n*-butyl nitrite[18] was added to the well-stirred solution at room temperature over a 50-min. period. After heating the mixture for 2 hr. at 100°, it was diluted with three volumes of water and extracted with three portions of benzene. The benzene extracts were washed with water, four portions of 10% sodium carbonate, and water.

The aqueous phases were combined and acidified with hydrochloric acid. The acid was extracted with benzene; the extracts were dried over magnesium sulfate and were distilled: b.p. 155–163° (16–17 mm.); 28.0 g. (57%). Curiously, the acids still had high neutralization equivalents and a repetition of the basic extraction using ether for the extracting solvent and redistillation (V-2) gave the pure acids whose yields and properties are listed in Table IV.

The neutral benzene extracts were combined, dried over magnesium sulfate, and distilled to furnish 19.2 g. (30%) of *butyl 2-ethyl-2-methyloctanoate:* b.p. 100–115° (1 mm.); n_D^{25} 1.4314. Redistillation (V-1) of this ester gave the purified ester: b.p. 141–144° (15–16 mm.); n_D^{25} 1.4306.

Anal. Calcd. for $C_{15}H_{30}O_2$: C, 74.32; H, 12.47; Saponification equiv., 242.4. Found: C, 74.10; H, 12.56; Saponification equiv., 241, 240.

Ten grams of this ester was heated under reflux for 6 hr. with 10 g. of potassium hydroxide in ethylene glycol. After the usual work-up 7.0 g. (91%) of 2-ethyl-2-methyloctanoic acid was obtained; b.p. 148–156° (17 mm.), n_D^{21} 1.4380.

Refractionation (V-1) of the homologous esters gave the purified esters listed in Table IV.

Hydrolysis of ethyl esters. 2-Ethyl-2-methylpentanoic acid. Ethyl 2-ethyl-2-methylpentanoate (120 g.) was heated under reflux for 5 hr. with 241 g. of potassium hydroxide in 1360 ml. of diethylene glycol. The mixture was diluted and extracted with ether to remove neutral materials. The aqueous phases were acidified and extracted with benzene. After the usual work-up the acid was distilled to give 91.5 g. (91%) of a single fraction: b.p. 127–128° (20–21 mm.); n_D^{25} 1.4278; neut. equiv., 145 (calcd., 144.21).

Saponification with alcoholic potassium hydroxide gave only a 30–35% yield. In ethylene glycol the yield was 50–60%.

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(18) W. A. Noyes, *Org. Syntheses*, Coll. Vol. II, 2nd. Ed., 108 (1943).

TABLE III

ALKYLATIONS TO PRODUCE ETHYL 2-ETHYL-2-METHYLALKANOATES

Starting Materials		Products, $R(C_2H_5)(CH_3)C—COOC_2H_5$						
$R_1R_2CHCOOC_2H_5$ R_1, R_2	RI R	R	B.P., (mm. Hg)	n_D^{25}	Sapon. Equiv. Calcd.	Sapon. Equiv. Found[a]	d^{25}	Yield, %
CH_3, C_2H_5	n-C_3H_7	n-C_3H_7	180–185 (752)[b]	1.4125	172.3	172	0.865	46.8
CH_3, n-C_3H_7	C_2H_5	n-C_3H_7	181–186 (754)[b]	1.4115	172.3	173	0.865	53.5
CH_3, C_2H_5	n-C_4H_9,	n-C_4H_9	94–95 (20)	1.4181	186.3	186[c]	0.863	41.2
C_2H_5, n-C_4H_9	CH_3	n-C_4H_9	94–97 (20)	1.4178	—	—	—	8.2
CH_3, C_2H_5	n-C_5H_{11}	n-C_5H_{11}	107–108 (20)	1.4238	200.3	199[d]	0.862	45.0

[a] Saponification equivalents were determined using potassium hydroxide in diethylene glycol. [b] Boiling point was also observed at 80–81° (20 mm.) The literature (ref. 5) reports, b.p. 180–185°. [c] *Anal.* Calcd. for $C_{11}H_{22}O_2$: C, 70.92; H, 11.90. Found: C, 71.10; H, 12.20. [d] Calcd. for $C_{12}H_{24}O_2$: C, 71.95; H, 12.07. Found: C, 71.54; H, 11.86.

TABLE IV

TRIALKYLACETIC ACIDS, $R—(C_2H_5)(CH_3)C—COOH$, AND BUTYL ESTERS BY HYDROLYSIS OF AMIDES

	Acid						Butyl Ester		
R—	B.P., (mm. Hg)	Yield[a]	n_D^{25}	d^{25}	Neut. Equiv. Calcd.	Neut. Equiv. Found	Yield[b]	B.P., (mm. Hg)	n_D^{25}
C_2H_5—	111–112 (16–17)[c]	50	1.4233	0.9273	130.2	131.3	27	90–92 (15)	1.4200
n-C_3H_7—	127–128 (21–22)[d]	50	1.4281	0.9177	144.2	144.9	12	103–105 (15)	1.4229
n-C_4H_9—	137–138 (16–17)[e]	44	1.4320	0.9096	158.2	158.3	27	117–118 (16)	1.4256
n-C_5H_{11}—	147–149 (16–17)[f]	48	1.4346	0.9022	172.3	172.4	28	129–131 (15)	1.4283
n-C_6H_{13}—	160–162 (16–17)[g]	51	1.4377	0.8982	186.3	186.2	30	141–144 (15–16)	1.4306

[a] Purified yield. [b] Crude yield. [c] The literature (ref. 6) gives b.p. 203–204°, [d] 125.5–126.5° (23 mm.), [e] 123–125° (22 mm.), [f] 131–135° (21 mm.), [g] 135–137° (19 mm.).

2-Ethyl-2-methylhexanoic acid was prepared using 102 g. of the ethyl ester, 180 g. of potassium hydroxide and 1020 ml. of diethylene glycol. The acid was obtained in 90.5% yield: 78.0 g.; b.p. 137–138° (16–17 mm.); n_D^{25} 1.4322; neut. equiv., 157 (calcd., 158.23).

2-Ethyl-2-methylheptanoic acid was prepared in 94% yield by boiling a mixture of 110 g. of the ethyl ester, 180 g. of potassium hydroxide, and 1020 ml. of diethylene glycol for 8 hr. The product boiled at 148–149° (17 mm.); 89.0 g.; n_D^{25} 1.4346; neut. equiv., 173 (calcd., 172.26).

Resolution of 2-ethyl-2-methylpentanoic acid with brucine. A mixture of 21.6 g. of the *dl*-acid, 59.1 g. of brucine, and 130 ml. of absolute ethanol was allowed to crystallize producing 39 g. of salt, m.p. 81–82°. Six more crystallizations furnished 13.8 g. of salt: m.p. 83°; $[\alpha]_D^{25}$ −38.06° (95% ethanol; c, 8). Decomposition of this brucine salt in hydrochloric acid, extraction with ether, and distillation gave 2.1 g. (10%) of (+)-*2-ethyl-2-methylpentanoic acid;* b.p. 127° (20 mm.); α_D^{25} +0.970° (homogeneous, 1 dm.); $[\alpha]_D^{25}$ +1.05°.

The mother liquors were concentrated according to the usual diamond scheme to give 29.0 g. of yellowish crystals: m.p. 80–81°, $[\alpha]_D^{25}$ −40.62° (95% ethanol; c, 8). Decomposition of this salt gave 2.7 g. of (−)-*2-ethyl-2-methylpentanoic acid;* b.p. 127° (20–21 mm.); $[\alpha]_D^{25}$ −0.58° (homogeneous).

An attempted resolution with quinine produced a 24% yield of quinine salt after seven crystallizations from ethanol: m.p. 131.5°; $[\alpha]$ −131.4° (95% ethanol; c, 8). Decomposition of this salt gave 2.3 g. of the acid: b.p. 128° (21 mm.); $[\alpha]_D^{25}$ −0.14°. The tail fraction gave the (+)-acid, $[\alpha]_D^{25}$ +0.12°. Cinchonine, strychnine, and (−)-α-phenylethylamine failed as resolving agents.

(+)-*2-Ethyl-2-methylhexanoic acid* was resolved in 5.1% yield by nine crystallizations of the brucine salt in ethyl acetate: the salt, m.p. 89°; the acid, b.p. 137° (17 mm.); α_D^{25} +1.12° (homogeneous, 1 dm.); $[\alpha]_D^{25}$ +1.23°.

The (−)-*acid* from the tail fraction had the value, $[\alpha]_D^{25}$ −0.58° (homogeneous).

(+)-*2-Ethyl-2-methylheptanoic acid* was resolved in 6.1% yield by eight crystallizations of the brucine salt from ethyl acetate: the salt; m.p. 73°; the acid, b.p. 148° (16–17 mm.); α_D^{25} +2.11° (homogeneous, 1 dm.); $[\alpha]_D^{25}$ +2.34°.

The tail fraction gave (−)-*acid,* $[\alpha]_D^{25}$ −1.13°.

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Substituted γ-Lactones. IV. Some Aldehyde Condensations with $\Delta^{\beta,\gamma}$-Angelica- and γ-Valerolactone[1]

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In connection with some previous work[4] we were interested in preparing γ-lactones with α-benzylidene or α-benzyl substituents. These compounds have potential value due to some of their pharmacological effects; they also serve as model compounds for further experiments directed towards the synthesis of lignans of the α,β-dibenzylbutyrolactone type.

In this note we describe some condensations of $\Delta^{\beta,\gamma}$-angelicalactone and γ-valerolactone with

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(1) Paper III of this series, see J. Rothe and H. Zimmer, *J. Org. Chem.*, **24**, 586 (1959).

(2) Taken from the M.Sc. Thesis of D. G., Univ. of Cincinnati (1958).

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(4) Part I, H. Zimmer and J. Rothe, *J. Org. Chem.*, **24**, 28 (1959).