TABLE III

ALKYLATIONS TO PRODUCE ETHYL 2-ETHYL-2-METHYLALKANOATES

Starting Materials		Products, $R(C_2H_5)(CH_3)C—COOC_2H_5$						
$R_1R_2CHCOOC_2H_5$	RI				Sapon. Equiv.			Yield,
R_1, R_2	R	R	B.P., (mm. Hg)	n_D^{25}	Calcd.	Found[a]	d^{25}	%
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		
	B.P.,				Neut. Equiv.			B.P.,	
R—	(mm. Hg)	Yield[a]	n_D^{25}	d^{25}	Calcd.	Found	Yield[b]	(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°.

CHEMISTRY DEPARTMENT
DE PAUL UNIVERSITY
CHICAGO 14, ILL.

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

HANS ZIMMER, DOLORES GRACIAN,[2] AND JOHANNES ROTHE[3]

Received November 5, 1959

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

(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).

(3) Chattanooga Medicine Company Post-Doctorate Research Fellow 1956–58.

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

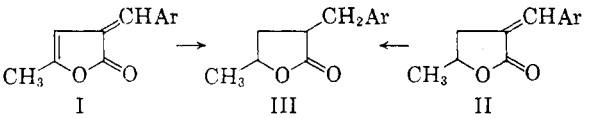
TABLE II

HYDROGENATION PRODUCTS, III

Cpd.	Yields from I	Yields from II	M.P.	Formula	Calcd. C	Calcd. H	Found C	Found H
IIIa	—	95	[a]	$C_{14}H_{19}NO_2$	72.07	8.21	71.28	8.25[d]
IIIb	70	97	62–64[b,c]	$C_{14}H_{18}O_4$	67.18	7.25	67.65	7.38
IIIc	41	90	68–69[c]	$C_{16}H_{22}O_4$	69.04	7.97	69.17	7.94

[a] B.p. 202–203°/4 mm. [b] B.p. 190–191°/1 mm. [c] Recrystallized from methanol. [d] Calcd.: N, 6.00. Found: N, 6.00.

certain aromatic aldehydes. Reactions of this type are known and give products of type I[5] and II.[6] In either case, 3-nitrobenzaldehyde furnished comparatively low yields of the desired condensation products, contaminated by large amounts of brown tars and resins. This fact confirm previous observations[4] regarding the influence of electron-withdrawing groups in the aromatic aldehyde on the result and yield of the reaction. Hydrogenations of either I or II led to α-benzyl-γ-valerolactones (III), the yields from II being comsiderably higher than from I.



I III II

a. Ar = 4-$CH_3NC_6H_4$; b. Ar = 3,4-$(CH_3O)_2C_6H_3$;
c. Ar = 3,4-$(C_2H_5O)_2C_6H_3$; d. Ar = 3-$O_2NC_6H_4$.

The structures of type I and type II compounds have been established (a) by carbon, hydrogen analysis, (b) infrared spectra, and (c) by the fact that they lead to identical hydrogenation products of type III.

EXPERIMENTAL

Melting points are uncorrected. Microanalysis are by A. Bernhardt, Microanalytisches Laboratorium im Max-Planck-Institut, Mülheim/Ruhr, Germany.

Materials. Generally Eastman White Label products were employed without further purification.

α-(4-Dimethylaminobenzylidene)-Δ$^{\beta,\gamma}$-angelicalactone (Ia). Δ$^{\beta,\gamma}$-Angelicalactone[7] (0.08 mole), 4-dimethylaminobenzaldehyde (0.1 mole) and diethylamine (*ca.* 2 ml.) were heated on a water bath for 1 hr. After cooling to room temperature, the excess aldehyde was removed by shaking with sodium bisulfite solution. The remaining yellow solid was filtered and recrystallized from methanol–petroleum ether (2:1); yield 7.4 g. (40%), orange leaflets, m.p. 120–121°.

Anal. Calcd. for $C_{14}H_{15}NO_2$: N, 6.11. Found: N, 6.23.

α-(3,4-Dimethoxybenzylidene)-Δ$^{\beta,\gamma}$-angelicalactone (Ib) was prepared similarly from veratraldehyde, but in benzene solution (initial cooling with water, then 30 min. heating on a water bath with stirring), to give yellow prisms from methanol, m.p. 118–119°, yield 40%. The compound slowly turns orange under the influence of light.

Anal. Calcd. for $C_{14}H_{14}O_4$: C, 68.28; H, 5.73. Found: C, 68.21; H, 5.64.

α-(3,4-Diethoxybenzylidene)-Δ$^{\beta,\gamma}$-angelicalactone (Ic) was prepared from 3,4-diethoxybenzaldehyde (no solvent, 40 min. heating on a water bath) to give yellow crystals from methanol, m.p. 100–101°, yield 43%.

Anal. Calcd. for $C_{16}H_{18}O_4$: C, 70.05; H, 6.61. Found: C, 69.85; H, 6.69.

α-(3-Nitrobenzylidene)Δ$^{\beta,\gamma}$-angelicalactone (Id) was prepared from 3-nitrobenzaldehyde (no solvent, initial cooling with ice salt, then standing overnight). The crude resinous product was dissolved in methylene chloride and chromatographed on neutral alumina. A yield of 70%, as yellow needles from methanol, m.p. 154–155°, was obtained besides much noncrystalline material.

Anal. Calcd. for $C_{12}H_9NO_4$: C, 62.34; H, 3.92; N, 6.06. Found: C, 62.12; H, 3.97; N, 6.30.

α-(4-Dimethylaminobenzylidene)-γ-valerolactone (IIa) was obtained from the aldehyde and γ-valerolactone in benzene with sodium methoxide as condensing agent (1.5 hr. stirring at room temperature; yield 69%; see ref. 4) as yellow leaflets from methanol, m.p. 130–131°.

Anal. Calcd. for $C_{14}H_{17}NO_2$: N, 6.06. Found: N, 6.11.

Similarly, the following were prepared: *α-(3,4-dimethoxybenzylidene)-γ-valerolactone* (IIb), m.p. 116° (from methanol); yield 54%.

Anal. Calcd. for $C_{14}H_{16}O_4$: C, 67.73; H, 6.50. Found: C, 67.51; H, 6.49.

α-(3,4-Diethoxybenzylidene)-γ-valerolactone (IIc), m.p. 110–112° (from methanol); yield 40%.

Anal. Calcd. for $C_{16}H_{20}O_4$: C, 69.54; H, 7.30. Found: C, 69.68; H, 7.12.

α-(3-Nitrobenzylidene)-γ-valerolactone (IId), m.p. 110–112°, yellow crystals from methanol; the product was isolated in a small yield only and was separated from much resinous material by chromatography of its solution in methylene chloride on alumina.

Anal. Calcd. for $C_{12}H_{11}NO_4$: C, 61.80; H, 4.75; N, 6.01. Found: C, 61.56; H, 4.89; N, 6.20.

Hydrogenations. These were performed using an Adams catalyst in methanol in a Parr apparatus (50 p.s.i. initial pressure). The results are tabulated below.

UNIVERSITY OF CINCINNATI
DEPARTMENT OF CHEMISTRY
CINCINNATI 21, OHIO

(5) J. Thiele, R. Tischbein and E. Lössow, *Ann.*, **319**, 180 (1901); W. F. v. Oettingen, *J. Am. Chem. Soc.*, **52**, 2024 (1930); P. B. Russel, A. R. Todd, and W. S. Waring, *Biochem. J.*, **45**, 530 (1949); D. H. Marrian, P. B. Russell, and A. R. Todd, *Biochem. J.*, **45**, 533 (1949); A. Dornow and G. Wedekind, *Arch. Pharm.*, **286**, 388 (1953).

(6) M. S. Losanitsch, *Monatsh.*, **35**, 311 (1914).

(7) J. H. Helberger, S. Ulubay, and H. Civelecoglu, *Ann.*, **561**, 215 (1949).

2-Acetyl-6-methoxycoumaran-3-one. Benzylation at the Terminal Methyl Group[1]

WM. IVO O'SULLIVAN AND CHARLES R. HAUSER

Received November 2, 1959

Wheeler and co-workers[2] have synthesized a number of coumaran-3-ones by rearrangement of the

(1) Supported by the Office of Ordnance Research, U. S. Army.