

104–105°. A white analytical sample was prepared by three precipitations from chloroform using petroleum ether and decolorizing with charcoal. *Anal.* Calcd. for $C_{10}H_7Br_2NO_4$: C, 32.9; H, 1.92; Br, 43.8. Found: C, 32.5; H, 1.88; Br, 43.5, 43.6, 43.9.

4-Amino-1,3-diacetylbenzene.—1,3-Dibromoacetyl-4-nitrobenzene (7.6 g.), 38 g. of stannous chloride dihydrate and 290 ml. of concentrated hydrochloric acid were stirred on a water-bath. After two and one-half hours the solution became yellow; the reaction mixture was then poured into 500 ml. of water and the resultant mixture made very basic with concentrated sodium hydroxide and then set aside in a refrigerator. A long yellow needled crystalline product was removed by filtration and recrystallized from water, yield 2.9 g., 78%, m. p. 139–140°. *Anal.* Calcd. for $C_{10}H_{11}NO_2$: C, 67.7; H, 6.21; N, 7.92. Found: C, 67.8; H, 6.46; N, 8.06.

4-Acetamino-1,3-diacetylbenzene.—A flask containing 1 g. of 4-amino-1,3-diacetylbenzene, 2.25 g. of acetic anhydride was placed in an oven at 42–46° overnight. The amino ketone went into solution, and the solution was poured into a small amount of water. An oily material which slowly crystallized separated, and after neutraliza-

tion of the solution with sodium carbonate was removed by filtration. The precipitate was recrystallized from *n*-heptane as long colorless needles, yield 1.1 g. (88%), m. p. 127–128°. *Anal.* Calcd. for $C_{12}H_{13}NO_3$: C, 65.6; H, 5.93; N, 6.40. Found: C, 65.75; H, 5.99; N, 6.44.

6-Acetyl-2,4-dimethylquinazoline.—A solution containing 1 g. of 4-acetamino-1,3-diacetylbenzene in 25 ml. of absolute alcohol was saturated with ammonia and then placed in a bomb. The bomb was maintained in an oven at 100–105° for seven and one-half hours. The yellow alcoholic reaction product was evaporated before a fan to dryness. A yellow residue was obtained which was dissolved in *n*-heptane, decolorized with charcoal and then recrystallized; yield 0.72 g. (76%) of white crystalline powder, m. p. 92°. *Anal.* Calcd. for $C_{12}H_{12}N_2O$: C, 71.9; H, 6.00; N, 14. Found: C, 71.6; H, 5.93; N, 13.7.

Summary

Directions for the synthesis of methyl 2,4-dimethyl-6-quinazolyl ketone from 4-nitroisophthalic acid are given.

CORVALLIS, OREGON

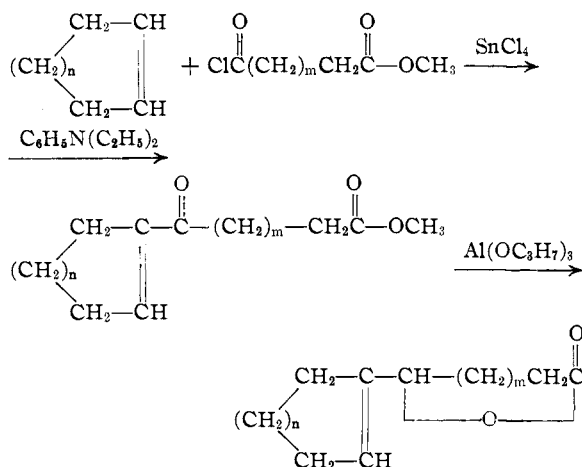
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[CONTRIBUTION FROM THE STERLING CHEMISTRY LABORATORY, YALE UNIVERSITY]

The Synthesis of Some Cycloalkenyl-substituted Butyro- and Valerolactones¹

BY JAMES ENGLISH, JR., AND JASON E. DAYAN²

As a part of the general problem of the study of compounds structurally related to auxin a,³ we have prepared a series of four lactones containing unsaturation in the position corresponding to that proposed by Kögl⁴ for the auxins. The method of synthesis is illustrated below; *n* and *m* were chosen as 1 and 2, in order to give representatives of both the cyclohexene and cyclopentene series, and of both γ - and δ -lactones in each case.



(1) Taken in part from the thesis submitted by Jason E. Dayan to the faculty of the Graduate School of Yale University, in partial fulfillment of the requirement for the degree of Doctor of Philosophy.

(2) General Aniline Works, Rensselaer, New York.

(3) J. English, Jr., and L. J. Lapidés, *THIS JOURNAL*, **65**, 2466 (1944); J. English, Jr., and J. Delafeld Gregory, *ibid.*, **69**, 2123 (1948); J. English, Jr., G. W. Barber and L. J. Lapidés, *ibid.*, **70**, 2859 (1949).

(4) F. Kögl and H. Erxleben, *Z. physiol. Chem.*, **235**, 181 (1935).

Reactions analogous to the first step, a modification of the procedure developed by Darzens,⁵ have been carried out by Rapson and Robinson⁶ and by Lapidés.⁷ In both cases, poor yields of unsaturated keto-esters were reported; in the present instance, despite extensive experimentation, the maximum yields of pure keto esters obtained was 30–35%. The use of less than equimolar amounts of stannic chloride⁸ and low reaction temperatures seemed to be the most important precautions necessary for optimum yields. The ultraviolet absorption spectra exhibited maxima at 234–240 $m\mu$ corresponding to that predicted⁹ for compounds of the proposed structure. The reduction of the keto acids proceeded smoothly with high yields of γ -lactones; the yields were considerably lower and more variable in the case of the δ -lactones and seemed to depend on the use of a carefully fractionated starting material.

The unsaturated lactones prepared were found to undergo extensive decomposition in the presence of traces of acid and colored compounds were produced also on saponification with alcoholic alkali. We have been unable to isolate the free hydroxy acids corresponding to the lactones reported in Table II, due, apparently, to production of colored acidic products that are convertible to the original lactones only in poor yields. Crystalline pseudo-benzylthiuronium salts of the hydroxy acids were readily obtained.

(5) G. Darzens, *Compt. rend.*, **150**, 707 (1910); **151**, 758 (1911).

(6) Rapson and R. Robinson, *J. Chem. Soc.*, 1285 (1935).

(7) Lapidés, Ph.D. Thesis, Yale University, 1944.

(8) Cologne and Moslavi, *Bull. soc. chim.*, **6**, 335 (1939).

(9) Woodward, *THIS JOURNAL*, **63**, 1123 (1941)

TABLE I

Compound	B. p., °C., 3 mm.	n_D^{20}	Absorption		Yield, %	Carbon, %		Hydrogen, %	
			max., $m\mu$			Calcd.	Found	Calcd.	Found
$C_6H_9CO(CH_2)_2COOCH_3$	133 ^a	1.4928	234	37	67.3	67.5	8.22	8.16	
$C_6H_9CO(CH_2)_3COOCH_3$	136 ^b	1.4920	234	34	68.5	68.3	8.56	8.32	
$C_5H_7CO(CH_2)_2COOCH_3$	118	1.4878	238	29	65.9	65.6	7.74	7.90	
$C_5H_7CO(CH_2)_3COOCH_3$	120	1.4844	240	22	67.3	67.5	8.22	8.05	

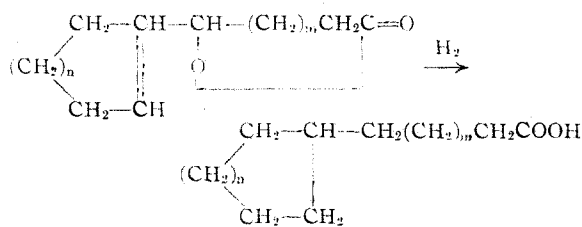
^a Semicarbazone, m. p. 147–148°. *Anal.* Calcd. for $C_{12}H_{19}O_3N_2$: N, 16.59. Found: N, 16.23. ^b Dinitrophenyl-hydrazone, m. p. 133–134°. *Anal.* Calcd. for $C_{18}H_{25}O_6N_4$: C, 55.4; H, 5.68. Found: C, 55.8; H, 5.55.

TABLE II

Compound	B. p., °C., 3 mm.	n_D^{20}	Yield, %	Pseudo-benzylthiuronium salt m. p., °C.	Carbon, %		Hydrogen, %	
					Calcd.	Found	Calcd.	Found
(1) $C_6H_9CH(CH_2)_2CO$	125–127	1.5041	91	120	72.3	72.6	8.32	8.5
(2) $C_6H_9CH(CH_2)_3CO$	123–124	1.4940	59	138	73.3	72.7	8.95	9.05
(3) $C_5H_7CH(CH_2)_2CO$	109.5–110	1.4950	94	122.5	71.0	71.4	7.95	8.27
(4) $C_5H_7CH(CH_2)_3CO$	125–126	1.4940	50	137	72.3	71.7	8.45	8.86

^a The pseudobenzylthiuronium salts of the free acids were prepared from a neutral aqueous alcoholic solution of their sodium salts by treatment with one equivalent of pseudobenzylthiuronium chloride in alcohol. The salts were rather soluble in dilute ethanol from which they were recovered by evaporation, and they were recrystallized from this same solvent to constant m. p. and elementary analysis. *Anal.* (1) Calcd. for $C_{18}H_{26}O_3N_2S$: C, 61.86; H, 7.48. Found: C, 61.76; H, 7.32. (2) Calcd. for $C_{19}H_{28}O_3N_2S$: C, 65.38; H, 7.73. Found: C, 65.56; H, 7.57. (3) Calcd. for $C_{17}H_{24}O_3N_2S$: C, 60.70; H, 7.19. Found: C, 60.86; H, 7.14. (4) Calcd. for $C_{18}H_{26}O_3N_2S$: C, 61.86; H, 7.48. Found: C, 61.96; H, 7.20.

Catalytic hydrogenation of the pure lactones proceeded in an abnormal manner. In all cases hydrogenation at room temperature with platinum catalysts produced the corresponding saturated acids, the hydroxyl group having undergone hydrogenolysis.



Experimental¹⁰

Preparation of Ketoesters.—One mole of the appropriate acid chloride (β -carbomethoxypropionyl chloride¹¹ or γ -carbomethoxybutyryl chloride¹⁰) was mixed with at least 2 moles of dry cyclopentene or cyclohexene in 180 g. of dry carbon disulfide. The mixture was protected from moisture, stirred and cooled to about -5° . There was then added 0.1 mole of anhydrous stannic chloride dissolved in 225 g. of carbon disulfide, maintaining the temperature below 0° . After the addition was complete (about one hour) the mixture was stirred for three hours longer, the temperature being allowed to rise gradually to about $5-10^\circ$. The contents of the flask were then poured into ice and dilute hydrochloric acid, the carbon disulfide layer separated, washed with cold water, and with sodium bicarbonate solution, and immediately mixed with 1 mole of diethylaniline. This entire operation was carried out as rapidly as possible, since serious loss of material results if the mixture stands in acid solution.

After removal of the carbon disulfide and excess hydro-

carbon at atmospheric pressure, the residue was heated in a bath at 180° for two hours. The flask was then cooled, the contents poured into cold dilute acid and the product extracted with ether, washed, dried and distilled through an efficient fractionating column. The properties and yields of the products obtained are given in Table I.

5-Cyclohexenyl-5-pentanoneoic Acid.—This substance was prepared in crystalline form from its ester by hydrolysis with alcoholic potassium hydroxide and recrystallization from water; white needles, m. p. 92° ; yield 85%. *Anal.* Calcd. for $C_{11}H_{16}O_3$: C, 67.3; H, 8.16. Found: C, 67.5; H, 7.96.

5-Cyclopentenyl-5-pentanoneoic Acid.—This acid was obtained in the same manner as the cyclohexenyl analog. It was an oil which could not be induced to crystallize; b. p. $178-181^\circ$ at 0.7 mm. *Anal.* Calcd. for $C_{10}H_{14}O_3$: C, 65.6; H, 7.69. Found: C, 65.4; H, 7.55.

Preparation of Lactones.—A solution of each of the above keto esters in 4 to 5 volumes of dry isopropyl alcohol was refluxed with an equimolar amount of aluminum isopropyl-

TABLE III

	Moles H_2 taken up	Products	M. p., °C.	Yield, %
$C_6H_9CH(CH_2)_2CO$	1.8	$C_6H_{11}(CH_2)_2COOH^a$	29.5–31	85
$C_6H_9CH(CH_2)_3CO$	1.6	$C_6H_{11}(CH_2)_3COOH^b$	6	60
$C_5H_7CH(CH_2)_2CO$	1.5	$C_5H_9(CH_2)_2COOH^c$ $C_5H_9CH(CH_2)_2CO^d$	26	45 35
$C_5H_7CH(CH_2)_3CO$	1.4	$C_5H_9(CH_2)_3COOH^e$ $C_5H_9CH(CH_2)_3CO^f$	14	45 30

^a THIS JOURNAL, 48, 239 (1926). ^b B. p. 151° (4 mm.), n_D^{20} 1.4661; THIS JOURNAL, 68, 1102 (1946); m. p. *p*-bromophenacyl ester 81° , no depression with authentic sample. ^c THIS JOURNAL, 50, 1503 (1928), b. p. 125° (4 mm.). ^d B. p. 126° (5 mm.); n_D^{20} 1.4751. *Anal.* Calcd. for $C_9H_{14}O_2$: C, 70.1; H, 9.15. Found: C, 70.1; H, 9.26. ^e THIS JOURNAL, 68, 1102 (1946). ^f B. p. 128° (3 mm.); n_D^{20} 1.4800. *Anal.* Calcd. for $C_{10}H_{16}O_2$: C, 71.39; H, 9.59. Found: C, 71.04; H, 9.27.

(10) All melting and boiling points are corrected.

(11) Cason, "Organic Syntheses," Vol. 25, John Wiley and Sons, Inc., New York, N. Y., 1943, p. 20.

ate under a simple fractionating column. Slow distillation was continued until no more acetone could be detected in the distillate (four to six hours). The remaining isopropyl alcohol was removed *in vacuo*, the residue hydrolyzed by pouring into an excess of cold dilute hydrochloric acid, and the product isolated by extraction with ether, washing with water, drying and distillation. The properties of the lactones as obtained by fractionation through a 20-plate column appear in Table II.

Hydrogenation of Lactones.—All of the lactones in Table II were hydrogenated in absolute ethanol with Adams platinum oxide catalyst at room temperature. The uptake of hydrogen varied with pressure and concentration of the solution, being greatest (close to 2 moles) in dilute solution at atmospheric pressure. The experiments

summarized in Table III were run at 40 p. s. i. in 5–10% solution. There is evidence from titration experiments for the presence of some saturated lactones in the fore fractions in the distillation of the hydrogenation products of the two cyclohexenyl lactones, but no pure products were obtained.

Summary

4-(1-Cyclohexenyl)- and 4-(1-cyclopentenyl)-butyrolactones and 5(1)-cyclohexenyl- and 5-(1-cyclohexenyl)-valerolactones have been synthesized. Hydrogenation of these lactones leads to hydrogenolysis of the lactone rings.

NEW HAVEN, CONN.

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[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF DUKE UNIVERSITY]

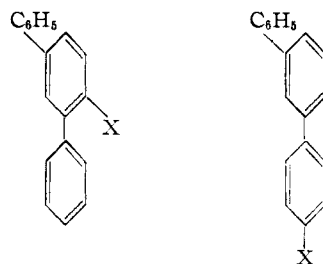
Reactions in the *m*-Terphenyl Series¹

By C. K. BRADSHER AND I. SWERLICK

In earlier work,^{2,3} it was demonstrated that 2-benzoyl- and 2-benzoyl-4,5-dimethylbiphenyl are useful intermediates in the synthesis of certain phenylphenanthrene derivatives. Since it appeared probable that the closely related 4'-benzoyl-*m*-terphenyl (I)⁴ might serve as a convenient starting material for the synthesis of some new diphenylphenanthrenes, experiments directed toward the synthesis of this previously unknown ketone (I) were undertaken. These experiments, together with others bearing on the problem of orientation in the *m*-terphenyl series, are the subject of the present communication.

Olgiati⁵ showed that the bromination of *m*-terphenyl in carbon disulfide yielded a crystalline monobromo derivative (m. p. 31°) to which, on the basis of oxidation products, he assigned the structure of 4'-bromo-*m*-terphenyl (II). From this bromo compound, by heating with cuprous cyanide, we have obtained 4'-cyano-*m*-terphenyl (III). The reaction of this nitrile with phenylmagnesium bromide afforded the desired 4'-benzoyl-*m*-terphenyl (I) in 62% yield. The nitrile (III), on hydrolysis, yielded the new 4'-*m*-terphenoic acid (IV). This acid was found to lose water when treated with concentrated sulfuric acid, yielding a compound which is presumably 3-phenylfluorenone.

Cook and Cook,⁶ by brominating molten *m*-terphenyl, obtained a liquid preparation which, on oxidation, gave evidence of only 4'-bromo-*m*-terphenyl (II). That this compound is the major product present is borne out by our observation that this liquid preparation gives fairly good yields of 4'-cyano-*m*-terphenyl. It is noteworthy that hydrolysis of the higher-boiling fraction from the



- | | |
|--|---|
| I, X = COC ₆ H ₅ | VI, X = COC ₆ H ₅ |
| II, X = Br | VII, X = Br |
| III, X = CN | VIII, X = CN |
| IV, X = COOH | IX, X = COOH |
| V, X = NH ₂ | X, X = NH ₂ |

nitrile synthesis yielded a small quantity of 4-*m*-terphenoic acid⁷ (IX) (identified as the methyl ester), the first evidence that direct bromination of *m*-terphenyl may yield some of the unknown 4-bromo-*m*-terphenyl (VII). The previous disagreement^{5,6} concerning the melting point of 4'-bromo-*m*-terphenyl, and the present evidence for the existence of 4-bromo- (VII) and 4-cyano-*m*-terphenyl (VIII) in our reaction products, made it seem worthwhile to prepare pure samples of these compounds.

The two halides (II and VII) were prepared from the appropriate amines by the Sandmeyer reaction. The 4'-bromo-*m*-terphenyl (II) prepared from a pure sample of 4'-amino-*m*-terphenyl⁸ (V) melted several degrees higher than the product⁵ obtained by direct bromination.

The 4-amino-*m*-terphenyl (X), prepared from the known⁷ 4-*m*-terphenoic acid by the Curtius reaction, was converted to the corresponding bromo compound (VII). The new 4-cyano-*m*-terphenyl (VIII) was obtained by dehydration of the corresponding amide by means of phosphorus trichloride.

Goodman and Lowy⁷ have investigated the

(7) Goodman and Lowy, *ibid.*, **60**, 2155 (1938).

(8) Wardner and Lowy, *ibid.*, **64**, 2510 (1932).

(1) This work was aided in part by a grant from the Duke University Research Council.

(2) Bradsher, *THIS JOURNAL*, **66**, 45 (1944).

(3) Bradsher and Wissow, *ibid.*, **68**, 2149 (1949).

(4) *Chemical Abstracts* numbering.

(5) Olgiati, *Ber.*, **27**, 3385 (1894).

(6) Cook and Cook, *THIS JOURNAL*, **55**, 1212 (1933).