that the inductive effect is not controlling. While the data could be explained in other terms[16] it seems to us that the acidity of the β-hydrogen is indeed the important factor since the observed order of E2 activation, Br > Cl > F, is just that which has been found for the effect of the various halogens on the rates of the base-catalyzed deuterium exchange of haloforms.[18] Possible reasons why the various halogens have the observed effect on the acidity of hydrogen atoms attached to the same carbon will be discussed subsequently in connection with data on the deuterium exchange of haloforms.

Experimental

Apparatus and Materials.—The constant temperature baths used and the purification of the organic bromides employed have been described previously.[5] Dioxane was purified by the method described by Fieser.[19] The vinyl bromide was distilled before use and stabilized with diphenylamine.

Kinetic Runs.—In a typical run 50 ml. of a thermostated dioxane solution, 0.1800 *M* in β-chloroethyl bromide and 0.01 *M* in diphenylamine,[20] was added by pipet to a 500-ml. volumetric flask in which 200 ml. of dioxane and 250 ml. of a standard aqueous solution, 0.04950 *N* in carbonate-free sodium hydroxide, had been mixed and allowed to reach thermal equilibrium. The flask was immediately shaken and at various times 50-ml. samples were withdrawn and titrated immediately with standard hydrochloric acid to the phenolphthalein end-point. In the runs with ethylene bromide and β-chloroethyl bromide at 70°, the samples were added to excess acid to stop the reaction and the excess acid was then back-titrated. In the other runs the amount of reaction that took place between sample withdrawal and the completion of the titration was negligible. In the calculation of rate constants allowance was made for the deviation from strict volume additivity in mixtures of water and dioxane.

Experiments designed to check our determinations of *f* were not successful. Analysis for ethylene oxide was not satisfactory because ethylene oxide is hydrated to ethylene glycol at a rate comparable to our reaction rates.[21] Hydration of ethylene oxide to ethylene glycol and titration of ethylene glycol with periodic acid was found to be unsuccessful because of interference by bromide ion.

Acknowledgments.—The authors would like to express their gratitude to the National Science Foundation for a grant in support of this investigation and to Dr. W. H. Brader, Jr., who made preliminary investigations on this problem.

---

[16] It seems unlikely, however, that the effect of β-halogens is due to differences in the relative stabilities of the rotational conformations. It must be the gauche conformation that undergoes the E2 reaction since only in this form is there a β-hydrogen atom *trans* to the bromine atom being displaced. Ethylene chloride has been shown to exist in the gauche form to a slightly larger extent than ethylene bromide under the same conditions.[17] From this fact we would expect the fractions of our halides in the reactive gauche form to vary in the order $FC_2H_4Br > ClC_2H_4Br > BrC_2H_4Br$ (the differences being small), the reverse of the observed order of E2 reactivities.

[17] S. Mizushima, Y. Morino, I. Watanabe, T. Simanouti and S. Yamaguchi, *J. Chem. Phys.*, **17**, 591 (1949).

[18] J. Hine, R. C. Peek, Jr., and B. D. Oakes, THIS JOURNAL, **76**, 827 (1954); J. Hine and N. W. Burske, *ibid.*, **78**, 3337 (1956); and unpublished data from this Laboratory.

[19] L. F. Fieser, "Experiments in Organic Chemistry," 2nd Ed., D. C. Heath and Co., Inc., New York, N. Y., 1941, part II, chap. III.

[20] In runs where no diphenylamine was used the rate constants climbed, apparently because of the dehydrohalogenation of polyvinyl halide.

[21] H. J. Lichtenstein and G. H. Twigg, *Trans. Faraday Soc.*, **44**, 905 (1948).

ATLANTA, GEORGIA

[CONTRIBUTION FROM THE MCPHERSON CHEMICAL LABORATORY, THE OHIO STATE UNIVERSITY]

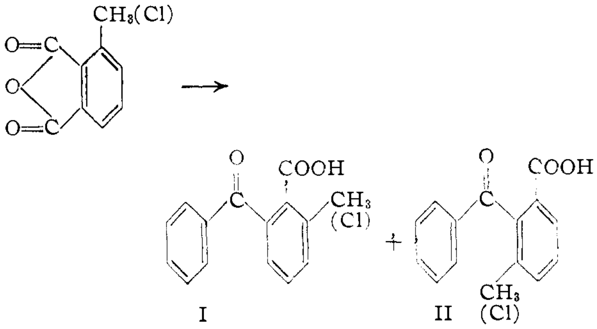
The Behavior of 3-Chlorophthalic Anhydride in Friedel–Crafts and Grignard Condensations

BY MELVIN S. NEWMAN AND PAUL G. SCHEURER[1]

RECEIVED MAY 16, 1956

The reactions of 3-chlorophthalic anhydride with benzene, *m*-xylene and mesitylene (Friedel–Crafts) and with phenyl-, *m*-xylyl- and mesitylmagnesium bromides are summarized. Condensation at the internal (hindered) carbonyl group takes place exclusively with benzene and *m*-xylene and predominantly with mesitylene. However, in the Grignard reactions, condensation occurs mainly at the external (unhindered) carbonyl group. The results are contrasted to previous results obtained with 3-methylphthalic anhydride.

In previous studies on the behavior of 3-methylphthalic anhydride, the respective reactivity of the carbonyl groups in the 1- and 2-positions were evaluated in the Grignard and Friedel–Crafts reactions by estimation of the isomeric benzoylbenzoic acids formed.[2] Reactions were carried out with phenylmagnesium bromide, 2,4-dimethyl- and 2,4,6-trimethylphenyl-magnesium bromides and with benzene, *m*-xylene and mesitylene in the Friedel–Crafts reaction in order to see what effect on the ratio of isomers formed there would be when 0, 1 and 2 methyl groups were *ortho* to the position of condensation. Reaction at the unhindered carbonyl yields products of general structure I whereas reaction at the hindered carbonyl yields products of structure II. The results are summarized in Table I.



I

II

---

[1] Taken from the Ph.D. thesis of P.G.S., The Ohio State University, 1953.

[2] (a) M. S. Newman and C. D. McCleary, THIS JOURNAL, **63**, 1542 (1941); (b) M. S. Newman and C. W. Muth, *ibid.*, **72**, 5191 (1950).

TABLE I

REACTIONS OF 3-METHYLPHTHALIC ANHYDRIDE AND 3-CHLOROPHTHALIC ANHYDRIDE IN GRIGNARD AND FRIEDEL–CRAFTS CONDENSATIONS

Reagent	3-Methyl,[2] % Reaction at carbonyl		3-Chloro, % Reaction at carbonyl	
	Unhindered Type I	Hindered Type II	Unhindered Type I	Hindered Type II
C_6H_5MgBr	43	14	52[a]	12[b]
2,4-$(CH_3)_2C_6H_3MgBr$	39	4	66	17[c]
2,4,6-$(CH_3)_3C_6H_2MgBr$	66	1	49	0[d]
Benzene	38	37	0	96.5
m-Xylene	42	32	0	89.5
Mesitylene	68	16	18.1	81.5

[a] This value includes about 4% isolated as phthalide. [b] 27% of unreacted anhydride was recovered. [c] 14% of anhydride recovered. [d] 35% of anhydride recovered.

The present work was undertaken to see what effect on the above ratios the substitution of a chlorine atom for a methyl group in the anhydride might have. Chlorine was chosen as a substituent rather than bromine, which is more nearly the same size as a methyl,[3] because less difficulty in regard to possible side reactions due to reactivity of the halogen was anticipated. Accordingly, the reactions of 3-chlorophthalic anhydride similar to those for 3-methylphthalic anhydride were carried out.

The results (Table I) indicate that while the reactions of 3-chlorophthalic anhydride with Grignard reagents are about the same as those of 3-methylphthalic anhydride, the Friedel–Crafts reactions are markedly different. A marked preference for reaction at the internal hindered carbonyl groups is apparent with the chloro anhydride but not with the methyl anhydride.

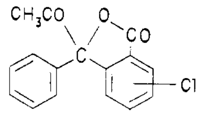
Preference for reaction at the hindered positions in polyfunctional compounds has been noted previously. For example, 3-nitrophthalic acid yields methyl 2-carboxy-6-nitrobenzoate on heating with methanol,[4] 2,6-dimethylterephthalic acid yields 3,5-dimethyl-4-aminobenzoic acid in the Schmidt reaction,[5] and in a series of 3-substituted phthalic acids, including 3-methyl and 3-chloro, the hindered carbonyl group is always replaced by amino in the Schmidt reaction.[6] Furthermore, in the Friedel–Crafts reaction of 3-substituted phthalic anhydrides with a variety of substrates preference for condensation at the central carbonyl has been observed.[7]

In view of this background, the non-specificity of 3-methylphthalic anhydride in the Friedel–Crafts reaction seems unusual. A discussion of reasons for the orientation of unsymmetrical anhydrides in Friedel–Crafts reactions has been presented[7] but will not be repeated in this paper.

The methods used for separation of the mixtures of acids of types I and II obtained in various runs are of interest. For the reactions of 2,4-dimethylphenylmagnesium and phenylmagnesium bromides with 3-chlorophthalic anhydride, the acid mixture was treated with diazomethane and the distilled methyl ester mixture dissolved in concd. sulfuric acid.[2b] The sulfuric acid solutions were poured on ice. The neutral fraction contained ester of type II and the acid fraction, a mixture of acid of type I and 3-chlorophthalic acid. Kinetic experiments (see Tables II and III) showed how long the sulfuric acid solutions required at about 25° for complete hydrolysis of the more rapidly hydrolyzing esters of type I. In the case of analogous methyl substituted esters[2b] the rates of hydrolysis were much more rapid, only a few minutes being required, whereas in the present examples 140–340 minutes were needed.

The mixture of acids formed in the Friedel–Crafts condensation of 3-chlorophthalic anhydride with mesitylene was separated by heating with methanol and hydrogen chloride. 2-(2,4,6-Trimethylbenzoyl)-6-chlorobenzoic acid was unchanged by this treatment while 2-(2,4,6-trimethylbenzoyl)-3-chlorobenzoic acid was esterified.

In some experiments it proved difficult to separate 3-chlorophthalic acid from the ketoacids produced. This separation was finally achieved in two cases by treating the mixture with acetyl chloride which converted 3-chlorophthalic acid to the anhydride and ketoacids to acetoxylactones of general structure III. When the mixture of anhydride and III was treated with dry methanol, the anhydride afforded half-esters of 3-chlorophthalic acid (alkali soluble) whereas the acetoxylactones III were unchanged and hence recoverable from the neutral fraction.



III

Experimental

3-Chlorophthalic Anhydride.[8]—Chlorine was bubbled through a sintered glass filter stick into molten 3-nitrophthalic anhydride (455.9 g.) heated to about 240°. Nitrogen dioxide was evolved even at 200° but much more copiously at 240° and ceased abruptly after 3.5 hours. On distillation at 52 mm. two fractions of crude 3-chlorophthalic anhydride, b.p. 205–208°, were obtained. To remove the adhering oil, both fractions were ground fine in a mortar, stirred well with a little ether, filtered and washed with more ether. The product, 346.5 g., m.p. 124–128°, was crystallized from 130 ml. of hot benzene. Ether, 230 cc., was added and the solid crushed, filtered and washed with 200 cc. of additional ether. A total of 341 g. (79%) of colorless 3-chlorophthalic anhydride, m.p. 124–126°, was obtained. On dissolving 3-chlorophthalic anhydride in concd. sulfuric acid (6 ml. per g.) and pouring this solution into water a quantitative yield of 3-chlorophthalic acid, m.p. *ca.* 186° dec., was obtained.

Dimethyl 3-chlorophthalate (1.97 g.) was dissolved in 20 ml. of concd. sulfuric acid and kept at about 25° for 75 minutes. On pouring this solution into water, an almost quantitative yield (1.52 g.) of 3-chlorophthalic acid was obtained.

---

[3] L. Pauling, "Nature of the Chemical Bond," Cornell University Press, Ithaca, N. Y., 1945, p. 189, gives the van der Waals radii of CH_3, Br and Cl as 2.00, 1.95 and 1.80 A., respectively.

[4] R. Wegscheider and A. Lipschitz, *Monatsh.*, **21**, 787 (1900); F. A. Abd Elhafez and D. J. Cram, THIS JOURNAL, **74**, 5846 (1952).

[5] M. S. Newman and H. Gildenhorn, *ibid.*, **70**, 317 (1948).

[6] Barkemeyer, M. S. thesis, Ohio State University, 1952; H. Shechter and T. Moritsugu, unpublished experiments. See Abstracts of papers presented at the meeting of the Am. Chem. Soc., Cincinnati, Ohio, March, 1955, p. 25N.

[7] For a complete literature review see the Ph.D. thesis of P. G. Scheurer, O.S.U., 1953. The evidence for the structure of many of the products is not convincing.

[8] See U. S. Patent 1,891,842; also *C. A.*, **26**, 5768 (1932); **44**, 7810b (1950).

Friedel–Crafts Reactions. (a) **With Benzene.**—A mixture of 7.30 g. of 3-chlorophthalic anhydride, 100 ml. of thiophene-free benzene and 11.2 g. of anhydrous aluminum chloride was refluxed for 4 hours. The reaction mixture was decomposed by adding ice and hydrochloric acid. No neutral fraction was obtained. From the acid fraction 9.86 g. (96.5%) of pure 2-benzoyl-3-chlorobenzoic acid, m.p. near 234°, was obtained. A sample, prepared for analysis by crystallization from methanol, melted at 232.8–234.2°.

Anal.[9] Calcd. for $C_{14}H_9ClO_3$: C, 64.5; H, 3.5. Found[9b]: C, 64.3; H, 3.6.

Methyl 2-benzoyl-3-chlorobenzoate was prepared by acid-catalyzed esterification in high yield. The analytical sample melted at 135.0–135.4° after crystallization from methanol.

Anal. Calcd. for $C_{15}H_{11}ClO_3$: C, 65.6; H, 4.0. Found[9b]: C, 65.3; H, 4.1.

(b) **With *m*-Xylene.**—A mixture of 2.20 g. of 3-chlorophthalic anhydride, 2.75 g. of *m*-xylene, 3.4 g. of aluminum chloride and 10 ml. of carbon disulfide was refluxed for 2 hours. The mixture was poured onto ice; no neutral product was obtained. The acid was purified by recrystallization from methanol to give 3.1 g. (89%) of 2-(2,4-dimethylbenzoyl)-3-chlorobenzoic acid, m.p. 172-181.5°. Repeated crystallization from methanol did not change the melting point.[10]

Anal. Calcd. for $C_{16}H_{13}ClO_3$: C, 66.5; H, 4.5. Found[9a]: C, 66.2; H, 4.5.

2-(2,4-Dimethylbenzoyl)-3-chlorobenzoic acid was esterified in the usual manner to give a 98.7% yield of the crude ester melting at 115–116°. Pure methyl 2-(2,4-dimethylbenzoyl)-3-chlorobenzoate, m.p. 116.0-116.5°, was obtained by crystallization from methanol.

Anal. Calcd. for $C_{17}H_{15}ClO_3$: C, 67.4; H, 5.0. Found[9a]: C, 67.6; H, 5.0.

(c) **With Mesitylene.**—A mixture of 5.15 g. of 3-chlorophthalic anhydride, 3.83 g. of pure mesitylene, 7.7 g. of aluminum chloride and 125 ml. of pure *sym*-tetrachloroethane, was heated at 80° for 2 hours. The mixture was poured on ice and yielded 8.23 g. (96.5% yield) of an acid fraction, m.p. 171-191°. No neutral fraction was obtained.

The isomeric acids present were separated as follows. The acid mixture (8.13 g.) was esterified with methanol containing hydrogen chloride by refluxing for several hours. The acid and ester fractions were separated and the acid fraction was refluxed with acid methanol for several hours. The combined acid fraction, m.p. 209-212°, amounted to 1.47 g. (18.1%) and the ester, m.p. 111-112°, amounted to 6.92 g. (81.5%). On crystallization from methanol pure 2-(2,4,6-trimethylbenzoyl)-6-chlorobenzoic acid melted at 210.0-211.0°, and similarly purified pure methyl 2-(2,4,6-trimethylbenzoyl)-3-chlorobenzoate melted at 112.4–112.8°.

Anal. Calcd. for $C_{17}H_{15}ClO_3$: C, 67.4; H, 5.0. Found[9b]: C, 67.3; H, 5.0. Calcd. for $C_{18}H_{17}ClO_3$: C, 68.2; H, 5.4. Found[9b]: C, 67.9; H, 5.2.

On refluxing with potassium hydroxide in ethylene glycol-water (2:1) for 16 hours, there was obtained 2-(2,4,6-trimethylbenzoyl)-3-chlorobenzoic acid from the methyl ester. Recrystallization from aqueous methanol afforded the pure acid, m.p. 203-204°. When mixed with the isomeric acid a depression in m.p. was observed.

Anal. Calcd. for $C_{17}H_{15}ClO_3$: C, 67.4; H, 5.0. Found[9b]: C, 67.5; H, 5.1.

Grignard Reactions of 3-Chlorophthalic Anhydride. (a) **Phenylmagnesium Bromide.**—In a typical Grignard reaction, 55 ml. of 0.97 *N* phenylmagnesium bromide was added in about 2 minutes with vigorous stirring to a solution of 9.18 g. of 3-chlorophthalic anhydride, in 90 ml. of thiophene-free benzene and 60 ml. of dry ether. After refluxing with stirring for about 20 hours, the reaction mixture was decomposed with dilute hydrochloric acid and separated into neutral and acid (13.4 g.) fractions. The neutral fraction was refluxed with aqueous potassium hydroxide and ethylene glycol for about 10 hours and the basic solution extracted with ether to remove biphenyl formed by coupling of the Grignard reagent. On acidification of the alkaline layer 0.74 g. of 4-chloro-1,1-diphenyl phthalide (see below) was obtained.

Anal. Calcd. for $C_{20}H_{13}ClO_2$: C, 74.9; H, 4.1. Found[9b]: C, 74.8; H, 3.9.

The acid fraction was analyzed as follows. The 13.4 g. of crude acid was refluxed for 3.3 hours with 40 g. of acetyl chloride and 71 ml. of acetic acid. The solvent was removed by blowing a stream of air into the heated flask and the residue taken up in ether–benzene and separated into neutral and acid fractions. From the acid fraction was obtained 0.69 g. of 3-chlorophthalic acid, m.p. and mixed m.p. *ca.* 186° dec. The neutral fraction (13.37 g.), a viscous oil, was dissolved in 100 ml. of absolute methanol and refluxed for 14 hours. The methanol was removed and the residue taken up in ether and separated into neutral and acid fractions. This acid fraction was separated with cold ether to yield 0.06 g. of insoluble 2-benzoyl-3-chlorobenzoic acid, m.p. about 226°, and 3.0 g. of ether-soluble methyl acid 3-chlorophthalate,[11] m.p. 164-166°. The neutral fraction consisted of the acetoxylactones, type III compounds, of the ketoacid. After alkaline hydrolysis the acids obtained from the acetoxylactones were treated with diazomethane to give esters which after vacuum distillation amounted to 8.22 g. as a light yellow viscous oil. Portions of the distilled ester were stirred with concd. sulfuric acid (10 ml./g.) until homogeneous. The solutions were allowed to stand at about 24° for varying periods of time and then poured on ice. The material obtained by two chloroform extractions was separated into neutral and acid fractions. The results of these experiments, listed in Table II, show that hydrolysis was essentially complete after about 130 minutes and complete after about 136 minutes. At this time 80% of the starting ester was converted to acid, which was undoubtedly essentially pure 2-benzoyl-6-chlorobenzoic acid,[12] and 20% of the ester was recovered as essentially pure methyl 2-benzoyl-3-chlorobenzoate, m.p. 134–135°. To sum up, of the 9.18 g. of 3-chlorophthalic anhydride used, 27.2% was obtained as unreacted methyl acid 3-chlorophthalate, 6.9% as 3-chlorophthalic acid, 47.6% as 2-benzoyl-6-chlorobenzoic acid (type II reaction product), 12.4% as methyl 2-benzoyl-3-chlorobenzoate (type I reaction product), and 4.1% as 4-chloro-1,1-diphenylphthalide.

4-Chloro-1,1-diphenylphthalide.—The small amount of neutral product obtained in the reaction of 3-chlorophthalic anhydride with phenylmagnesium bromide was shown to be the phthalide by mixed m.p. comparison with an authentic sample prepared as follows. A mixture of 0.36 g. of 2-benzoyl-6-chlorobenzoic acid and 2 g. of oxalyl chloride was warmed for 11 hours. The excess oxalyl chloride was removed under reduced pressure and the residue dissolved in 10 ml. of pure dry benzene. On adding 0.4 g. of anhydrous aluminum chloride hydrogen chloride was evolved rapidly. After warming for 90 min., the reaction mixture was worked up to yield 0.30 g. of neutral product, m.p. 154–155°, after crystallization from benzene–petroleum ether.

Anal. Calcd. for $C_{20}H_{13}ClO_2$: C, 74.9; H, 4.1. Found[9b]: C, 74.8; H, 3.9.

(b) ***m*-Xylylmagnesium Bromide.**—To a well-stirred solution of 22.20 g. (0.122 mole) of 3-chlorophthalic anhydride in 120 ml. of thiophene-free benzene and 70 ml. of dry ether was added rapidly (2 min.) 145 ml. of 0.84 *N* *m*-xylylmagnesium bromide. After stirring at reflux for 20 hours the mixture was treated with dilute acid. No neutral fraction was obtained. The acid fraction after treatment with diazo-

---

[9] Analyses: (a) by Mr. J. Kraus, (b) by Clark Microanalytical Laboratories, Urbana, Ill., (c) by Galbraith Microanalytical Laboratories, Knoxville, Tenn.

[10] The fact that the same melting point range was observed for the ketoacid when regenerated by saponification of the methyl ester, m.p. 116.0–116.5°, can be taken as evidence for the purity of the acid. The melting point range is apparently due to a polymorphic transformation taking place at about 172°. When this temperature is approached slowly, the compound sinters. It is all melted at 181.5°.

[11] R. F. Bird and E. E. Turner, *J. Chem. Soc.*, 5050 (1952).

[12] The m.p. of this acid was not sharp when crystallized from benzene, carbon tetrachloride or aqueous acetic acid. In each case the crystals retained solvent even after prolonged heating at 80° under reduced pressure. The m.p. was unsharp in the range 90–117° and during melting bubbling indicated loss of solvent. We were unable to obtain a sample of acid which gave an accurate analysis. Heating of the melted samples evidently caused some decarboxylation as judged by the analytical results. Methylation afforded a noncrystalline ester. Hence it was difficult to establish purity of the acidic product of hydrolysis. However, the pure acid (structure proved by decarboxylation) had the same properties.

TABLE II

HYDROLYSIS IN CONCENTRATED SULFURIC ACID OF MIXED METHYL ESTERS OF 2-BENZOYL-3-CHLORO- AND 2-BENZOYL-6-CHLOROBENZOIC ACIDS AT ABOUT 25°

Distilled esters,[a] g.	Time, min.	Ester obtained, g.	Acid obtained, g.	Hydrolysis,[b] %
1.03	5	0.84	0.18	19
0.92	15	.58	.32	37
1.23	20	.64	.60	48
0.87	30	.41	.44	53
0.91	35	.40	.48	56
2.47	50	.91	1.58	63
0.87	70	.24	0.62	73
1.23	90	.29	.93	76
0.87	110	.19	.65	78
1.23	130	.26	.96	79
0.87	150	.18	.65	80

[a] In all experiments 10 ml. of concd. sulfuric acid per g. of ester mixture was used. [b] % hydrolysis = g. distilled ester − g. ester obtained/g. distilled ester × 100.

methane yielded 34.3 g. of ester, a portion of which was vacuum distilled to give ester for sulfuric acid hydrolysis as described above. The results are listed in Table III. The unhydrolyzed ester proved identical to methyl 2-(2,4-dimethylbenzoyl)-3-chlorobenzoate, m.p. and mixed m.p. 114–116°. The acidic material was refluxed with aqueous potassium hydroxide[13] and acidified. A benzene solution of the acids deposited a quantity of 3-chlorophthalic acid. The remaining acid was obtained by adding petroleum ether to the benzene solution and recrystallizing from benzene until pure. The m.p. was 114–115°. For proof of structure see the designated section.

Anal. Calcd. for $C_{16}H_{13}ClO_3$: C, 66.5; H, 4.5. Found[9b]: C, 66.8; H, 4.7.

TABLE III

HYDROLYSIS IN CONCENTRATED SULFURIC ACID OF MIXED METHYL ESTERS OF 2-(2,4-DIMETHYLBENZOYL)-3-CHLORO- AND 2-(2,4-DICHLOROMETHYLBENZOYL)-6-CHLOROBENZOIC ACIDS AT ABOUT 25°

Distilled esters,[a] g.	Time, min.	Ester obtained, g.	Acid obtained, g.	Hydrolysis,[b] %
1.18	30	0.75	0.45	36
0.85	94	.32	.39	62
1.30	120	.46	.77	65
6.72	128	1.57	4.36	68
1.39	290	0.27	1.04	80
1.82	540	.30	1.42	83

[a] In all experiments 10 ml. of concd. sulfuric acid per g. of ester mixture was used. [b] % hydrolysis = g. distilled ester − g. ester obtained/g. distilled ester × 100.

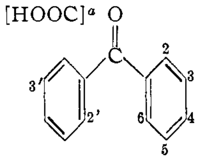
The results of this entire experiment are summarized in Table I.

(c) **Mesitylmagnesium Bromide.**—To a well-stirred solution of 20.06 g. (0.110 mole) of 3-chlorophthalic anhydride in 140 ml. of benzene and 70 ml. of ether was added during two minutes 100 ml. of 1.14 *N* mesitylmagnesium bromide. The mixture was refluxed for 24 hours and then decomposed with dilute acid. No neutral fraction was obtained. The crude acid fraction, 25.90 g., was refluxed with acid methanol for 4 hours and the product separated into neutral and acid fractions. The esterification was repeated for 7 hours with the acid fraction, the product separated into neutral and acid fractions and the latter again esterified for 14 hours. The total free acid amounted to 20.77 g., m.p. 200–208°, and the ester fraction, 6.08 g. Recrystallization of 2.40 g. of the acid afforded 2.23 g. of pure 2-(2,4,6-trimethylbenzoyl)-6-chlorobenzoic acid, m.p. 210–212°. The ester proved to be almost pure dimethyl 3-chlorophthalate as a portion on alkaline hydrolysis yielded only 3-chlorophthalic acid and another portion on digestion with concd. sulfuric acid was completely hydrolyzed. If any methyl 2-(2,4,6-trimethylbenzoyl)-3-chlorobenzoate had been at hand, it would have remained unhydrolyzed (blank experiment). The total results of these experiments are recorded in Table I.

Proof of Structure of Ketoacids.—All ketoacids (about 1–2 g.) were heated with copper powder (Venus-copper bronze) in quinoline until evolution of carbon dioxide was complete. This usually required 0.5–1 hour and was indicated by darkening of the reaction mixture and smooth instead of bumpy refluxing. The solid ketones were compared by mixed melting point determinations with authentic synthetic samples. The ketones were all obtained in high yields. The authentic ketones, all of which are new compounds except for 3-chlorobenzophenone[14] and 2-chlorobenzophenone,[15] were prepared in over 80% yields by Friedel–Crafts condensations of *o*- and *m*-chlorobenzoyl chlorides with benzene, *m*-xylene and mesitylene. The properties of the ketones and analyses are listed in Table IV.

TABLE IV

PROPERTIES OF NEW KETONES



	M.p.,[b] °C.	Analyses,[c] % Calcd. C	Calcd. H	Found C	Found H
2′-Cl-2,4-$(CH_3)_2$[d]	[f]	74.0	5.4	74.0	5.3
3′-Cl-2,4-$(CH_3)_2$	57.6–58.4	74.0	5.4	73.8	5.6
2′-Cl-2,4,6-$(CH_3)_3$[e]	101.4–101.8	74.2	5.8	73.9	5.8
3′-Cl-2,4,6-$(CH_3)_3$[e]	85.4–86.0	74.2	5.8	74.3	5.6

[a] When the ketones below were prepared by decarboxylation the carboxyl group had the position shown in parentheses. [b] The m.p. of these ketones were not depressed when mixed with samples prepared by decarboxylation. [c] Analyses on ketones prepared by Friedel–Crafts reaction. [d] The DNPH derivative melted at 221.0–222.5° alone and mixed with the DNPH prepared by decarboxylation. *Anal.* Calcd. for $C_{21}H_{17}ClN_4O_4$: C, 59.4; H, 4.0. Found[9b]: C, 59.6; H, 3.9. [e] We were unable to prepare carbonyl derivatives of these ketones. [f] B.p. 178° at 4 mm.

The reaction mixture was then treated with excess 6 *N* hydrochloric acid and the organic material taken into ether, washed with acid and alkali and distilled under reduced pressure. Comparison of the low melting, 48–49°, 2-chlorobenzophenone,[15] was effected through the ketone and the 2,4-dinitrophenylhydrazone. Two polymorphic 2,4-dinitrophenylhydrazones were obtained in the case of 2-chlorobenzophenone from both the synthetic sample and that obtained by decarboxylation of 2-benzoyl-3-chlorobenzoic acid. These forms frequently crystallized in separate clumps of crystals from the same solution. They could be separated by hand. In chloroform solution both gave identical infrared absorption spectra. The lower melting form, m.p. 177–178°, crystallized in rosettes of fine red-orange needles from benzene–alcohol, and the high melting form, m.p. 182–184°, crystallized in stout transparent orange prisms.

Anal. Calcd. for $C_{19}H_{13}ClO_4N_4$: Cl, 8.9; N, 14.1. Found[9c] (for both forms): Cl, 9.0; N, 14.0.

COLUMBUS, OHIO

---

[13] This treatment was thought necessary to hydrolyze any half-esters of 3-chlorophthalic acid that might have been present. Later work, however, showed that after 75 minutes at 24° dimethyl 3-chlorophthalate is completely hydrolyzed by sulfuric acid.

[14] F. A. Koopal, *Rec. trav. chim.*, **34**, 153 (1915), gives a m.p. of 82–83° for 3-chlorobenzophenone.

[15] C. Graebe and F. Keller, *Ber.*, **32**, 1687 (1899), and P. J. Montagne and S. A. Koopal, *Rec. trav. chim.*, **29**, 138 (1910), report a m.p. of 45.5°, whereas K. von Auwers, M. Lechner and H. Bundesmann, *Ber.*, **58**, 50 (1925), report a m.p. of 52–56°; E. Berliner, THIS JOURNAL, **66**, 533 (1944), reports a m.p. of 43–44°.