

chlorides have been prepared and characterized, the ortho derivative being reported for the first time.

2. The preparation and properties of the new mercurials 4-fluoro-3-chloro-mercuribenzoic acid and 4-fluoro-2-acetoxymercuriphenol are reported.

3. The preparation and melting points are given for 4-fluoro-3-aminobenzoic acid, its hydrochloride and acetyl derivative and the decomposition point for 2-fluoro-5-carboxybenzenediazonium fluoborate, all of which are new.

BALTIMORE, MARYLAND

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[CONTRIBUTION FROM THE COBB CHEMICAL LABORATORY, UNIVERSITY OF VIRGINIA]

## The 1,4-Diphenyl-2-mesityl 1,4-Diketones

BY ROBERT E. LUTZ AND CHARLES J. KIBLER

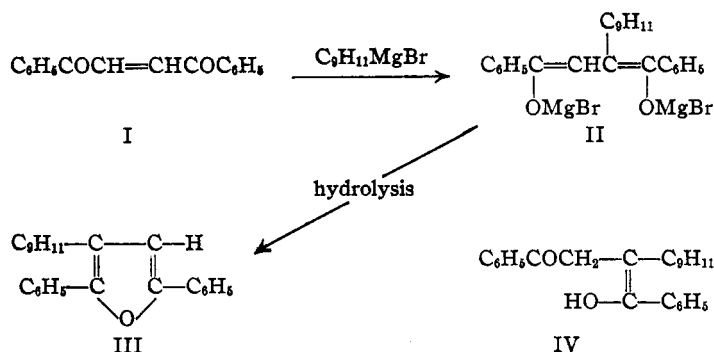
The preparation of this series of compounds was undertaken in order to study the effect of reactions of a mesityl group substituted directly at the ethylene linkage of the unsaturated 1,4-diketone system, and to determine the effect of this mesityl group on the tautomerism of the corresponding triketone enol and hydroxyfuranone.

The starting point in the synthesis was dibenzoyl ethylene, I. Mesitylmagnesium bromide adds to the unsaturated diketone readily, presumably through 1,4-addition followed by enolization at the remaining carbonyl, to give the dienolate II.<sup>1</sup> On hydrolysis 2,5-diphenyl-3-mesitylfuran, III, was formed exclusively and in good yield, with no indication of the formation of the expected and hoped for saturated diketone,  $C_6H_5COCH_2CH(C_6H_{11})COC_6H_5$ , which remains as yet unknown. This result is not particularly surprising, however, since it is known that phenylmagnesium bromide adds to dibenzoylstyrene with the formation of large amounts of the corresponding tetraphenylfuran along with the expected saturated diketone, tetraphenyl-1,4-butanedione.<sup>1b,2</sup> The mesityl group not only offers no hindrance to furanization but actually facilitates the reaction considerably. It seems very likely that the dienolic intermediate II on hydrolysis undergoes prompt ketonization at the unhindered enolic group to produce the mono-enol, IV, with a normally reactive carbonyl now available for furan ring closure, and with the remaining and hindered enolic group, in the favorable configuration indicated, persisting long enough for reaction to be complete even under these mild conditions.

(1) Cf. (a) Lutz and Tyson, *THIS JOURNAL*, **56**, 1341 (1934); (b) Lutz and Reveley, *ibid.*, **61**, 1854 (1939).

(2) Hahn and Murray, *ibid.*, **30**, 1484 (1914).

The unsaturated 1,4-diketone of this series, VI, is easily obtained by the nitric-acetic acid oxidation of the furan, III, and is assigned the *cis* configuration on the basis of this mode of preparation.<sup>3</sup> It is reduced easily by zinc and acetic acid, sodium hydrosulfite, and catalytic hydro-

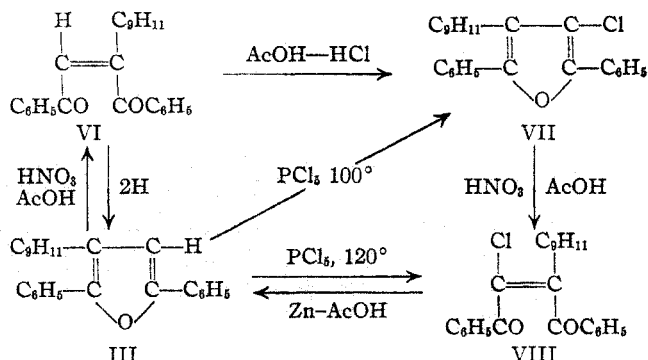


gen; but the furan III was the only crystalline product obtained. In the catalytic hydrogenation an attempt was made to follow the course of the reaction. Piperidine was added in the hope that ketonization would be catalyzed with the production of the saturated diketone instead of the furan. A non-crystalline product was obtained which spontaneously on standing for eight days, or immediately when treated with acetic anhydride and sulfuric acid, gave the furan, and which very evidently contained the mono-enol IV. Undoubtedly, then, the reduction was 1,6.

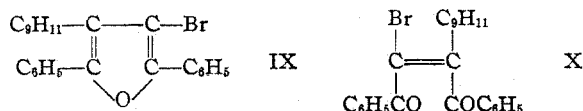
The unsaturated diketone VI reacts with dry hydrogen chloride in acetic acid to give the chlorofuran VII which is obtained also by direct chlorination of the furan III with phosphorus pentachloride at 100° (at a higher temperature, however, some of the unsaturated chloro diketone VIII is

(3) Cf. (a) Lutz and Wilder, *ibid.*, **56**, 979 (1934); (b) Lutz, Tyson, Sanders and Fink, *ibid.*, **56**, 2679 (1934); (c) Lutz and Wilder, *ibid.*, **56**, 2145 (1934); (d) Lutz and Eisner, *ibid.*, **56**, 2698 (1934).

formed through the oxidizing action of the reagent<sup>3c</sup>). The nitric-acetic acid oxidation of the chlorofuran gives the unsaturated chloro diketone in good yield. This compound as would be expected is reduced by zinc and acetic acid to the furan III. The structures of these halogen derivatives are evident from their modes of formation and from their reactions as outlined in the diagram.



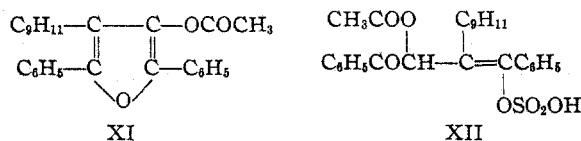
The bromofuran IX was obtained by reactions similar to those described above, from the furan III and phosphorus pentabromide, and from the unsaturated diketone VI and hydrogen bromide in acetic acid or phosphorus pentabromide. Oxidation of the bromofuran gives the unsaturated bromo diketone X which is reduced directly to the furan III by zinc and acetic acid.



In the reactions of diphenylmesitylfuran described above, it is noteworthy that halogenation occurs readily and only in the vacant  $\beta$ -position in the furan nucleus. Evidently the mesityl group does not hinder substitution or oxidative ring fission.

The unsaturated diketone VI reacts with acetic anhydride and sulfuric acid to give the acetoxyfuran XI, a reaction not easily carried out on types with mesityl groups in the terminal positions and directly attached to the carbonyl groups.<sup>4</sup> The mechanism of the reaction very probably involves 1,4-addition of acetic anhydride or its equivalent (such as a mixed anhydride, to give XII as intermediate) followed by

furanization between the enolized group and the remaining and reactive carbonyl group.



In conclusion it may be stated that the substitution of mesityl in the 2-position on the chain of dibenzoylethylene and in the  $\beta$ -position of the furan nucleus has introduced no unexpected hindrance to typical reactions.

The synthesis and study of the triketone enolhydroxyfuranone tautomerism in this series is in progress.

### Experimental Part

**2,5-Diphenyl-3-mesitylfuran, III.**—Seven grams of powdered dibenzoylethylene in 1-g. portions was added with efficient stirring to a solution of three equivalents of mesitylmagnesium bromide in 60 cc. of absolute ether. The reaction was immediate and vigorous. The resulting clear brownish solution was refluxed for fifteen minutes and decomposed in ice water acidified with hydrochloric acid. The product, isolated by extraction with ether, was digested with ethanol, the furan crystallizing in nearly pure condition in 65% yield. It crystallized from acetone as flat colorless needles melting at 157.5–158°.<sup>5</sup>

*Anal.* Calcd. for  $C_{25}H_{22}O$ : C, 88.7; H, 6.55. Found: C, 88.6, 88.8; H, 6.6, 6.7.

An attempt was made to show that the furan was not actually formed until after hydrolysis or partial hydrolysis by carrying out the reaction in the presence of an excess of iodine for the purpose of oxidizing the dienol as fast as it was liberated. Only the furan was obtained. This is without significance, however, since the rate of furanization is evidently unusually high and since one case is now known where a dienol, oxidizable by air, is rearranged instead into the saturated diketone when treated with iodine under conditions similar to those employed here (namely, the dienol formed in the catalytic reduction of the dimolecular alkaline condensation product of di-(trimethylbenzoyl)-ethylene<sup>6</sup>).

The furan reacted with three parts of phosphorus pentachloride when the two solids were fused together and heated at 100° for one hour. Largely unchanged material was obtained on hydrolysis of the reaction mixture, but a small amount of the chlorofuran VII was isolated upon fractional crystallization. In a similar experiment with heating for five minutes at 120°, followed by hydrolysis and fractional crystallization, again unchanged material was recovered together with a small amount of the chloro unsaturated diketone VIII. The furan reacted at room temperature with five parts of phosphorus pentabromide with the formation of a red oil which was allowed to stand

(4) Cf. Lutz and Wood, *THIS JOURNAL*, **60**, 229 (1938). 1,2,4-Trimesityl-2-butenedione-1,4 and 1,4-dimesityl-2-phenyl-2-butenedione-1,4 do not give acetoxyfurans under the usual conditions (Lutz and Kibler, papers to appear shortly).

(5) The melting points of all analytical samples are corrected.

(6) Lutz and Disque, unpublished results.

for twenty-five minutes. On hydrolysis and crystallization of the resulting solid product from ethanol, the bromofuran X was obtained in 64% yield.

**cis-1,4-Diphenyl-2-methyl-2-butenedione-1,4** (Dibenzoylmesitylethylene), VI.—A suspension of 5 g. of diphenylmesitylfuran III in 25 cc. of concd. acetic acid, cooled to 10°, was treated with 20 cc. of a 1-3 mixture of concd. nitric and acetic acids, also cooled to 10°. The furan dissolved immediately with evolution of oxides of nitrogen. The solution was allowed to stand at 10° for one hour and was then decomposed in water. After several hours the coagulated product was filtered off and crystallized from ethanol, giving 4.3 g. (90%) of nearly pure material. It crystallized from ethanol or methanol as rectangular plates or rosetts melting at 98.5-99.5°.

*Anal.* Calcd. for  $C_{26}H_{22}O_2$ : C, 84.7; H, 6.3. Found: C, 84.5; H, 6.3.

Sunlight was without action on the unsaturated diketone in ethanol solution or in chloroform containing iodine.

**Reduction.** (a) A mixture of 0.5 g. of the unsaturated diketone, an excess of zinc dust, and 50 cc. of concd. acetic acid was allowed to react in the cold and was then heated slowly to boiling. The furan III was the sole product isolated; yield 65%. Similar results were obtained when the zinc dust was added to a boiling solution of the unsaturated diketone in concd. acetic acid.

(b) A mixture of 0.5 g. of sodium hydrosulfite, 0.5 g. of the unsaturated diketone and 70% ethanol was refluxed for thirty minutes and diluted with water. Fractional crystallization from ethanol gave 0.2 g. of the furan and 0.15 g. of unchanged material.

(c) A solution of 0.5 g. of the unsaturated diketone in 70% ethanol with 0.1 g. of platinum oxide catalyst absorbed one molecule of hydrogen in fifteen minutes. Filtering and diluting with water and extracting with ether gave an oil which could not be induced to crystallize. A sample of the oil was treated with acetic anhydride containing a trace of sulfuric acid; on subsequent hydrolysis the product crystallized without difficulty and proved to be the furan. The oily product on standing for eight days deposited crystals of the furan which was identified.

**4-Chloro-2,5-diphenyl-3-mesitylfuran, VII.**—A solution of 0.7 g. of the unsaturated diketone VI in 20 cc. of concd. acetic acid was saturated at room temperature with dry hydrogen chloride. In a short time 0.42 g. of analytically pure chlorofuran VII crystallized as truncated prisms melting at 102.5-103.5°. On diluting the filtrate with water 0.15 g. of nearly pure furan was obtained; total yield 77%. Further crystallization of the main product did not change the melting point.

*Anal.* Calcd. for  $C_{26}H_{21}OCl$ : Cl, 9.5. Found: Cl, 9.6.

**cis-3-Chloro-1,4-diphenyl-2-mesityl-2-butenedione-1,4, VIII.**—A suspension of 0.15 g. of the chlorofuran VII in 2 cc. of concd. acetic acid was treated with 0.2 cc. of a mixture of 0.2 cc. of concd. nitric acid and 0.5 cc. of concd. acetic acid, at room temperature. After standing for ten minutes the furan dissolved and 0.1 g. of the unsaturated chloro diketone VII crystallized as thick hexagonal plates melting at 127.5-128°. Recrystallization from methanol and from ethanol did not change the melting point.

*Anal.* Calcd. for  $C_{26}H_{21}O_2Cl$ : C, 77.2; H, 5.46. Found: C, 77.2; H, 5.3.

**Reduction** to the furan III was effected quickly in the usual way by the action of zinc dust in boiling concd. acetic acid (one minute).

**4-Bromo-2,5-diphenyl-3-mesitylfuran, IX.**—To a solution of 0.5 g. of VI in 5 cc. of concd. acetic acid at room temperature was added slowly 2 cc. of a 30% solution of hydrogen bromide in concd. acetic acid. The product crystallized and after standing for five minutes the solution was partly diluted with water and the product crystallized from ethanol, giving 0.37 g. (65%) of nearly pure bromofuran IX. It was purified by further crystallizations from isopropanol; truncated prisms of melting point 126-127°.

*Anal.* Calcd. for  $C_{26}H_{21}OBr$ : C, 71.9; H, 5.1. Found: C, 72.1; H, 5.4.

In an alternative procedure 0.1 g. of VI was mixed thoroughly with 0.5 g. of phosphorus pentabromide and allowed to react for an hour, the temperature being maintained at 0°. Hydrolysis and crystallization from ethanol gave 0.07 g. of pure bromofuran.

**cis-3-Bromo-1,4-diphenyl-2-mesityl-2-butenedione-1,4, X.**—A solution of 0.3 g. of the bromofuran IX in 3 cc. of concd. acetic acid was treated with 1 cc. of a 1-3 mixture of concd. nitric and acetic acids at room temperature. After standing for fifteen minutes the product was precipitated with water and crystallized from ethanol; yield 95%. It crystallized from methanol as hexagonal plates melting at 103-104.5°. It was stable in the solid state in the dark but turned deep pink when exposed to light. Ethanol solutions appeared not to be affected by exposure to sunlight.

*Anal.* Calcd. for  $C_{26}H_{21}O_2Br$ : C, 69.3; H, 4.9. Found: C, 68.8, 69.5; H, 5.0, 5.2.

**Reduction** to the furan III was effected quickly by zinc dust and concd. acetic acid (one minute) in the usual way.

**4-Acetoxy-2,5-diphenyl-3-mesitylfuran, XI.**—A solution of 0.5 g. of VI in 10 cc. of acetic anhydride was treated with 10 drops of concd. sulfuric acid. Reaction was indicated by coloration and warming. After standing for five minutes and hydrolysis in ice water, the product was isolated by extraction with ether. It crystallized (cubic) from ethanol; yield, 0.44 g. (78%); m. p. 124.5-126.5°. It was not very stable and further crystallization by the ordinary methods lowered the melting point.

*Anal.* Calcd. for  $C_{27}H_{24}O_3$ : C, 81.8; H, 6.1. Found: C, 82.2, 82.1; H, 6.4, 6.5.

## Summary

Mesitylmagnesium bromide adds 1,4 to dibenzoylethylene but gives diphenylmesitylfuran instead of the expected saturated diketone.

The unsaturated diketone was made by the nitric-acetic acid oxidation of the furan. Reduction of this gives the furan, even with catalytic hydrogen in 70% ethanol. It was converted into an acetoxyfuran.

The chloro and bromo derivatives of the furan hinder typical reactions. and the unsaturated diketone are described.

The presence of the mesityl group does not

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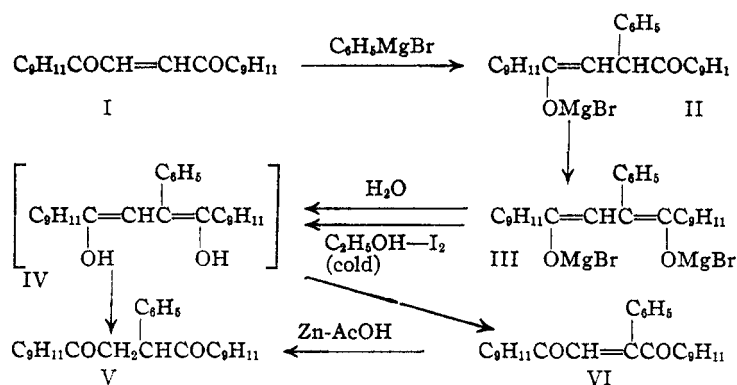
## The 1,4-Dimesityl-2-phenyl 1,4-Diketones

BY ROBERT E. LUTZ AND CHARLES J. KIBLER

This series of compounds has been made in order to study the effect of terminal mesityl groups on the reactions of the saturated and unsaturated 1,4-diketone systems and on the ease of furan ring closure and ring fission. Interest centers in a comparison of the reactions of this series with, first, those of di-(trimethylbenzoyl)-ethylene, I, and, second, those of dibenzoylphenylethylene,  $\text{C}_6\text{H}_5\text{COCH}=\text{C}(\text{C}_6\text{H}_5)\text{COC}_6\text{H}_5$ . In the case of di-(trimethylbenzoyl)-ethylene the reactions of the conjugated systems are relatively unimpaired and like those of dibenzoylphenylethylene itself, but of course the individual carbonyl group reactivities are lowered. In the case of dibenzoylphenylethylene, as compared with dibenzoylphenylethylene, the full conjugated system is nearly as easily reduced, one  $\alpha,\beta$ -unsaturated ketone system appears to react normally with the other definitely hindered, the ethylene linkage is unreactive as also is one of the carbonyls, but furan ring closure is if anything facilitated as also is the reverse reaction, oxidative fission of the furan ring.

1,4-Dimesityl-2-phenyl-1,4-butanedione, V, has been made from di-(trimethylbenzoyl)-ethylene, I, by 1,4-addition of phenylmagnesium bromide,<sup>1</sup> the reaction proceeding as indicated in the diagram through the monoenolate II to the dienolate III. The proof that the excess of phenylmagnesium bromide causes the enolization of II to III rests on the hydrolysis of the product under oxidizing conditions with the formation of the unsaturated 1,4-diketone, VI, which could only have been produced by oxidation of the dienol IV.<sup>2</sup> The reaction between the Grignard reagent and di-(trimethylbenzoyl)-ethylene, then, can be manipulated to give good yields of the unsaturated diketone, VI. Since the nitric-acetic acid oxidation

method has proved to be useless in the case of 2,5-dimesitylfurans, this oxidation of the dienol becomes the logical preparative method.



Dibenzoylphenylethylene and dibenzoylmesitylphenylethylene, whatever the method of synthesis, appear to have the *cis* configuration with respect to the aroyl groups, and are obtainable by the oxidation both of the corresponding furans and the dienols.<sup>2,3</sup> It is probable, therefore, that the unsaturated diketone under discussion, VI, is also *cis*.

Reduction of the unsaturated diketone proceeds easily with zinc and acetic acid to give the saturated diketone exclusively.

Furan ring closure from the saturated diketone, V, could not be brought about by the usual procedure using acetic anhydride and sulfuric acid. Since di-(trimethylbenzoyl)-ethane itself cannot be dehydrated under these conditions,<sup>4</sup> it might appear that ring closure by this method is to some extent hindered by the mesityl groups; however, di-(trimethylbenzoyl)-dimethylethane,  $\text{C}_6\text{H}_{11}\text{COCH}(\text{CH}_3)\text{CH}(\text{CH}_3)\text{COC}_6\text{H}_{11}$ , is furanized with extraordinary ease under comparable conditions.<sup>5</sup> It can only be said that the 1,4-dimesityl com-

(1) Lutz and Tyson, *THIS JOURNAL*, **56**, 1341 (1934).

(2) Lutz and Reveley, *ibid.*, **61**, 1854 (1939).

(3) (a) Lutz and Wilder, *ibid.*, **56**, 979 (1934); (b) Lutz, Tyson, Sanders and Fink, *ibid.*, **56**, 2679 (1934); (c) Lutz and Kibler, *ibid.*, **61**, 3007 (1939).

(4) Lutz, Johnson and Wood, *ibid.*, **60**, 716 (1938).

(5) Lutz and Taylor, *ibid.*, **55**, 1593 (1933).