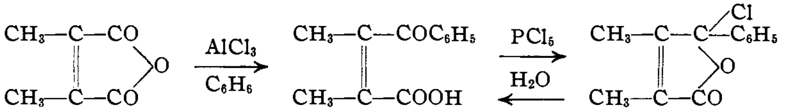
[CONTRIBUTION NO. 108 FROM THE COBB CHEMICAL LABORATORY OF THE UNIVERSITY OF VIRGINIA]

Studies on Unsaturated 1,4-Dicarbonyl Compounds. IX. Aryl Unsaturated 1,4-Diketones and Ketonic Acids Derived from Dimethyl Maleic and Fumaric Acids

BY ROBERT E. LUTZ AND ROBERT J. TAYLOR*

This paper deals with the synthesis and preliminary study of a new series of compounds which should yield diastereoisomeric reduction products. A study of the stereochemistry of reduction is in progress in this Laboratory and will be treated in a later paper.

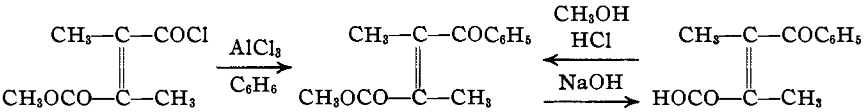
Cis-β-benzoyldimethylacrylic Acid (II).—The Friedel and Crafts reaction on dimethylmaleic anhydride gives *cis*-benzoyldimethylacrylic acid (II) in good yield as the sole product. The configuration must be *cis* corresponding with that of the starting material, because the isomer (obviously the *trans*) is obtained exclusively in a synthesis from dimethylfumaric acid, and because the acid chloride (III) does not give any detectable amount of a diketone in the Friedel and Crafts reaction, in contrast with the *trans* isomer which behaves normally in this respect.



I II III

The methyl ester is easily made and is hydrolyzed to the acid again in good yield. It is quite stable in solution toward iodine and sunlight, and cannot be prepared from the *trans* isomer by the action of sunlight alone. The configurations of these dimethyl compounds, then, are relatively stable as compared with those of the unsubstituted aroyl acrylic esters.

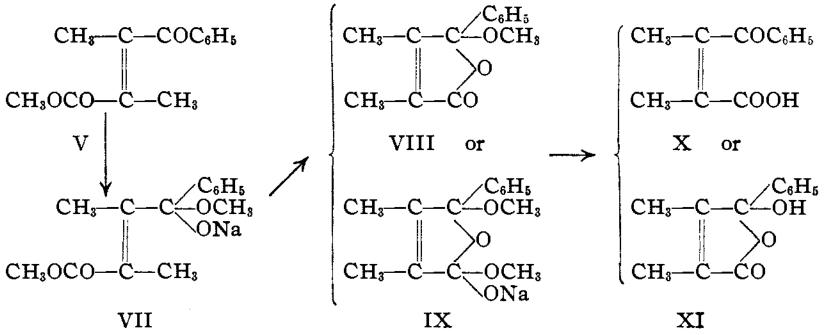
Trans-β-benzoyldimethylacrylic Acid (VI).—*Trans*-benzoyldimethylacrylic methyl and ethyl esters (V) were obtained as the sole products of the Friedel and Crafts reaction on the corresponding acid chlorides of dimethylfumaric monoalkyl acid esters (IV). Hydrolysis of these esters in dilute alcohol gives the corresponding *trans* acid exclusively, no trace of the *cis* isomer being found. The *trans* acid is easily esterified, and gives a normal acid chloride (XVII) which undergoes the Friedel and Crafts reaction to give the expected diketone (XV), although in poor yield. The *trans* configuration follows from these relationships.



IV V VI

(*) Du Pont de Nemours Fellow, 1931–1932.

Inversion from Trans to Cis.—*Trans*-benzoyldimethylacrylic methyl ester is hydrolyzed with sodium methylate in methanol, to give exclusively the *cis* acid, although in poor yield. This inversion is analogous with that of dimethylfumaric dimethyl ester during hydrolysis under similar conditions.[1] The change apparently takes place during or preceding hydrolysis because the *trans* acid, once formed, is stable under these conditions. The 1,4-addition of sodium methylate might occur as an intermediate step; but compounds resulting from such additions are known[2] and do not lose methanol easily except at elevated temperature. Another possible mechanism, as outlined in the following diagram, involves the addition of sodium methylate to one or both of the carbonyl groups, followed by cyclization (the driving force causing inversion) and hydrolysis; this would explain the direction of rearrangement, which is opposite that which might be expected on the basis of the generally greater stability of *trans* forms.



The γ-hydroxy crotolactone formulas (VIII, IX, XI) are analogous with the Anschütz formulas for maleic acid and ester types,[3] and the cyclic formulation of maleil and *cis* aroyl acrylyl chlorides[4] and the various lactonic forms of some substituted aroyl acrylic acids and esters.[4d] A choice between the two formulations of *cis*-benzoyldimethylacrylic acid might possibly be made in favor of the cyclic type (XI) on the basis of the slow rate of solution of the acid in cold sodium bicarbonate, as contrasted with the rapidity with which the *trans* isomer dissolves under these conditions.

β-(2,4,6-Trimethylbenzoyl)-dimethylacrylic Acid. XII.—A trimethylbenzoyldimethylacrylic acid (XII) is obtained in good yield in the Friedel and Crafts reaction on dimethylmaleic anhydride, but this same acid is also obtained by hydrolysis of the methyl ester which was made similarly from dimethylfumaric monomethyl ester mono-acid chloride (IV). Both

---

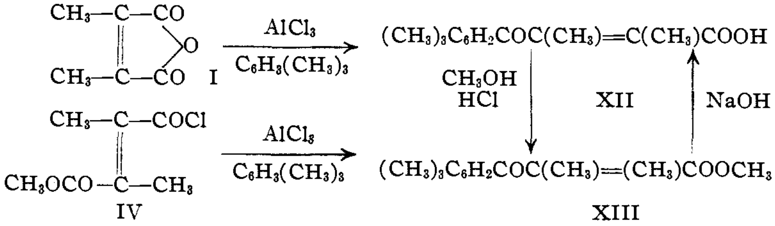
[1] (a) Auwers, *Ber.*, **62**, 1678 (1929); (b) Lutz and Taylor, THIS JOURNAL, **55**, in press (1933).

[2] *I. e.*, 1,2-dibenzoylmethoxyethane; Lutz, THIS JOURNAL, **51**, 3008 (1929); dimethylmethoxysuccinic acid (Ref. 1b); *cf.* discussion (Ref. 1b).

[3] Anschütz, *Ann.*, **254**, 168 (1889); **461**, 155 (1928). See also Ref. 1a.

[4] (a) Lutz, THIS JOURNAL, **52**, 3405 (1930); (b) Lutz and Taylor, *ibid.*, **55**, 1168 (1933); (c) Ott, *Ann.*, **392**, 270 (1912); (d) Allen and Frame, *Canadian J. Research*, **6**, 605 (1932).

acid and ester must correspond in configuration since they can be converted one into the other by hydrolysis and esterification, involving conditions under which inversion is unlikely.



Obviously in one of these two Friedel and Crafts reactions rearrangement has occurred; there is ample analogy for supposing an inversion from *cis* to *trans* in the reaction between citraconic anhydride and mesitylene,[1] and in all of the Friedel and Crafts reactions on maleic anhydride itself;[5] on the other hand, there is no such analogy for the reverse rearrangement from *trans* to *cis*. The configuration of this trimethylbenzoyldimethylacrylic acid, then, is very probably *trans*. A study of the acid chloride failed to yield pertinent information.

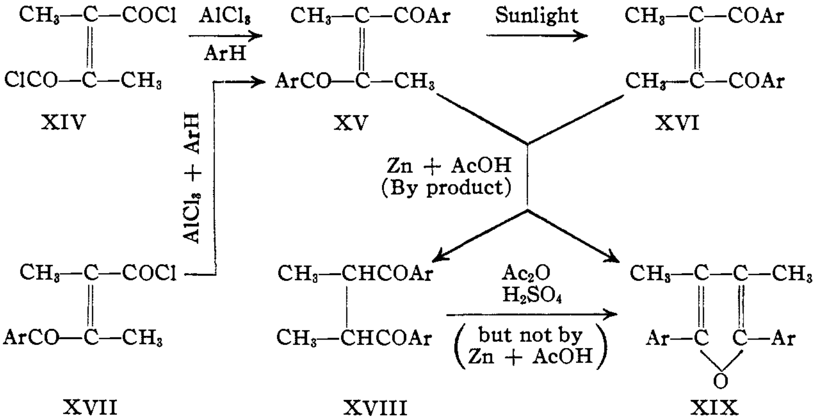
The Dimethyl Unsaturated 1,4-Diketones (XV).—The *trans* aryl unsaturated 1,4-diketones are prepared in good yield by the Friedel and Crafts reaction on dimethylfumaryl chloride (XIV). The dibenzoyl derivative is obtained also, though in poor yield, from *trans*-benzoyldimethylacrylyl chloride (XVII). The preparation of the *cis* isomers (XVI), however, proved extremely difficult, and was not accomplished in the case of the dibenzoyl derivative. Curiously the *trans*-di-trimethylbenzoyl derivative, the most difficult to isomerize in the unsubstituted series,[6] was partially isomerized in very poor yield by the action of sunlight on a benzene solution. The structure of this *cis* isomer was shown by reduction to the same products obtained from the *trans* isomer. It proved to be stable, however, and did not rearrange back to the *trans* isomer under the influence of iodine and sunlight. It is decomposed when treated with aluminum chloride in carbon disulfide, whereas the *trans* isomer is stable under these conditions. The configuration of the *trans* isomer is clear from its synthesis, and that of the *cis* isomer from its mode of formation from the *trans* by the action of sunlight.

The 1,6-Addition of Hydrogen to the Dimethyl Unsaturated 1,4-Diketones.—The dimethyl unsaturated 1,4-diketones are reduced easily with zinc and acetic acid to give mainly the furan (XIX). One of the two theoretically possible stereoisomeric saturated 1,4-diketones (XVIII) was isolated also in the case of the reduction of the di-trimethylbenzoyl derivative; it proved to be stable under the conditions of the reduction

---

(5) Lutz, THIS JOURNAL, **52**, 3423 (1930).

(6) Conant and Lutz, *ibid.*, **45**, 1303 (1923).



Ar = aromatic radical, phenyl or mesityl.

as was shown in a separate experiment; but it was very easily converted into the furan by treating with acetic anhydride and a trace of concd. sulfuric acid. The saturated 1,4-diketone is not an intermediate in the reaction since it is stable under these conditions. The formation of the furan can best be accounted for by the spontaneous dehydration of an intermediate dienol, $ArC(OH){=}C(CH_3)C(CH_3){=}C(OH)Ar$, XX, which is postulated in the theory of 1,6-addition of hydrogen to unsaturated 1,4-dicarbonyl types. A full discussion of this evidence has been given in an earlier paper.[7] The fact that both the *cis* and *trans* isomers are reduced to the same products (the furan and only one of the two possible saturated 1,4-diketones) *in almost exactly the same ratio*, would be difficult to explain on the basis of simple addition of hydrogen to the ethylene linkage, but is easily accounted for by assuming the intermediate dienol (XX) in which the double bond responsible for the stereoisomerism has been destroyed.

Experimental Part

Dimethyl Unsaturated 1,4-Ketonic Acids

Cis-2-benzoyl-1,2-dimethylacrylic Acid (II).—The Friedel and Crafts reaction with benzene on dimethylmaleic anhydride in benzene as the solvent gave difficultly hydrolyzable amorphous products containing aluminum. Using carbon disulfide this difficulty was largely eliminated.

Five grams of dimethylmaleic anhydride was added slowly to a well-stirred suspension of 10.6 g. of anhydrous aluminum chloride in 25 cc. of benzene and 25 cc. of carbon disulfide. The red reaction mass was heated for one and one-half hours on the steam-bath. The carbon disulfide layer after hydrolysis in ice gave upon evaporation 4 g. of nearly pure *cis* acid (49%): cryst. from chloroform; sol. in benzene and hot water; m. p. 94° (corr.); dissolves slowly in cold sodium bicarbonate solution, but rapidly in sodium carbonate; precipitated by acid.

Anal. Calcd. for $C_{12}H_{12}O_3$: C, 70.55; H, 5.92. Found: C, 70.72; H, 5.88.

A sample of the *cis* acid, exposed to direct sunlight for three days in chloroform with

---

[7] Lutz, THIS JOURNAL, **51**, 3008 (1929).

iodine, was recovered quantitatively unchanged. Using bromine instead of iodine, only unchanged material and non-crystalline resinous by-products were isolated.

The acid chloride was prepared by the action of the calculated amount of phosphorus pentachloride on the *cis* acid. It was a viscous yellow oil which decomposed in attempting distillation under reduced pressure. It hydrolyzed easily to the *cis* acid on standing with water. The Friedel and Crafts reaction on a sample of the oil gave only resinous products from which in one case a small sample (0.05 g.) of an unidentified solid of m. p. 211° was isolated. Varying conditions did not give better results.

Cis-2-benzoyl-1,2-dimethylacrylic Methyl Ester, $C_6H_5COC(CH_3)=C(CH_3)COOCH_3$.—A solution of 12 g. of *cis* acid in 25 cc. of absolute methanol saturated with hydrogen chloride was allowed to stand overnight, and was then decomposed in ice and sodium carbonate and extracted with ether. The ether solution, dried over potassium carbonate, was evaporated. The bulk of the residual oil distilled at 163–164° (9 mm.) in a yield of 10.3 g. (77%), and solidified on cooling: cryst. from 70% ethanol, m. p. 53° (corr.).

Anal. Calcd. for $C_{13}H_{14}O_3$: C, 71.52; H, 6.47. Found: C, 71.42; H, 6.38.

A sample of the ester, exposed to direct sunlight in chloroform with iodine for fifteen hours, was recovered quantitatively unchanged.

Hydrolysis.—One gram of the ester was allowed to stand overnight in 10 cc. of 95% ethanolic sodium hydroxide (1 equiv.). The product was isolated by diluting the solution with water and extracting with ether; yield 0.88 g. (94%) of nearly pure *cis* acid.

Trans-2-benzoyl-1,2-dimethylacrylic Acid (VI).—The ethyl ester (1 g.) was treated with 13 cc. of a 70% ethanol solution of 0.22 g. of sodium. The mixture was allowed to stand for twenty hours, was then diluted with water, acidified and extracted with ether; yield of nearly pure material 0.83 g. (94%); cryst. from benzene; m. p. 119° (corr.); sol. in hot water; dissolves quickly in sodium bicarbonate solution.

Anal. Calcd. for $C_{12}H_{12}O_3$: C, 70.55; H, 5.92. Found: C, 70.54; H, 6.09.

Trans-2-benzoyl-1,2-dimethylacrylic Methyl Ester (V).—Dimethylfumaric monomethyl ester mono-acid chloride (6.5 g.) was added to a well-stirred suspension of 8 g. of aluminum chloride in 50 cc. of benzene. The yellow reaction mixture was heated on a steam-bath for twenty minutes, and was decomposed in ice and hydrochloric acid in the usual way. The benzene layer was dried with anhydrous sodium sulfate and distilled at 4.5 mm. pressure, the bulk of the product boiling at 139–143°; yield, 6.5 g. (81%); colorless oil, b. p. 141° (corr.) at 5 mm.

Anal. Calcd. for $C_{13}H_{14}O_3$: C, 71.52; H, 6.47. Found: C, 71.42; H, 6.52.

Hydrolysis of 2 g. in 15 cc. of an ethanol solution of 0.22 g. of sodium gave 1.06 g. (57%) of *trans* acid.

Hydrolysis and Rearrangement of Trans-benzoyldimethylacrylic Methyl Ester.—The *trans* ester (0.9 g.) was treated with 10 cc. of absolute ethanol containing 0.15 g. of dissolved sodium. Crystals appeared during the twenty-four hours of standing. The mixture was then diluted with water, acidified and extracted with ether. The acidic products were extracted from the ether by sodium carbonate and liberated by acidification as an oil which crystallized. It was recrystallized from water, to yield 0.3 g. of nearly pure *cis*-benzoyldimethylacrylic acid which was identified by mixed melting point. No trace of the *trans* acid was detected. The balance of the material was accounted for as an oil which did not crystallize.

A sample of *trans*-benzoyldimethylacrylic acid under identical reaction conditions was recovered quantitatively unchanged.

Trans-2-benzoyl-1,2-dimethylacrylic Ethyl Ester, $C_6H_5COC(CH_3)=C(CH_3)COOC_2H_5$.—Prepared in the same way as the methyl ester, starting with dimethylfumaric monoethyl acid ester; colorless oil, b. p. 120° (corr.) at 2 mm.

Anal. Calcd. for $C_{14}H_{16}O_3$: C, 72.37; H, 6.95. Found: C, 72.18; H, 6.94.

Hydrolysis of 1 g. of the ester in absolute ethanol with one equivalent of sodium ethylate gave an oily product from which steam distillation gave 0.45 g. of yellow oil which probably contained ethyl phenyl ketone (characteristic odor), although isolation of its oxime failed. From the residue on acidification and extraction with ether 0.07 g. of crude *cis*-benzoyldimethylacrylic acid was isolated, recrystallized, and identified by a mixed melting point. No *trans* acid was detected.

Trans-2-benzoyl-1,2-dimethylacrylyl Chloride (XVII).—The *trans* acid (0.5 g.) was treated with the calculated amount of phosphorus pentachloride. The oily reaction mixture, without isolating the acid chloride, was subjected to the Friedel and Crafts reaction with benzene and aluminum chloride, following the usual procedure.[8] An oil was obtained from which 0.08 g. of pure dibenzoyldimethylethylene was isolated and identified by a mixed melting point.

The acid chloride and phosphorus oxychloride mixture from 0.5 g. of acid was heated for one hour with 0.7 g. of aluminum chloride. Upon hydrolysis of the red reaction product, 0.17 g. of pure *trans* acid was recovered and identified.

A sample of the acid chloride in contact with water was hydrolyzed to the acid in less than one hour.

Trans-2-(2,4,6-trimethylbenzoyl)-1,2-dimethylacrylic Acid (XII).—The Friedel and Crafts reaction on dimethylmaleic anhydride with mesitylene was run on a small scale to ensure complete reaction and to avoid long continued heating, which results in the formation of complex resinous products containing aluminum.

Five grams of dimethylmaleic anhydride was added slowly to a well-stirred mixture of 10.6 g. of aluminum chloride in 6 g. of mesitylene and 50 cc. of carbon disulfide. The red viscous reaction mixture was heated for one hour on the steam-bath, and was decomposed in ice and hydrochloric acid. The carbon disulfide layer on evaporation gave a resinous mass which crystallized from benzene and gave 6 g. (61.5%) of nearly pure product; cryst. from benzene; colorless; m. p. 169.5° (corr.); sol. in chloroform, insol. in water.

Anal. Calcd. for $C_{15}H_{18}O_3$: C, 73.13; H, 7.37. Found: C, 73.07; H, 7.41.

The acid chloride was obtained as a yellow oil by the action of phosphorus pentachloride on the acid. It decomposed when distillation under reduced pressure was attempted. It was isolated by extracting a petroleum ether solution with water to remove phosphorus oxychloride, and evaporating the petroleum ether *in vacuo*. A sample was hydrolyzed slowly in contact with water to the acid which was identified. The Friedel and Crafts reaction was attempted under a variety of conditions in petroleum ether and in carbon disulfide, but the formation of the expected diketone was not observed in any case.[9] In one experiment a small amount of a colorless solid of m. p. 198–199° (corr., decomp.), crystallizing from benzene, was obtained. It gave an analysis of C, 77.81; H, 7.42. We did not have sufficient material for further study.

Trans-2-(2,4,6-trimethylbenzoyl)-1,2-dimethylacrylic Methyl Ester (XIII).—The ester was obtained in a rather poor yield in a typical Friedel and Crafts reaction with mesitylene and dimethylfumaric monomethyl ester monochloride, in carbon disulfide. It was best prepared by esterification of the acid.

A solution of 10 g. of the acid in absolute methanol was saturated with hydrogen chloride and allowed to stand for twenty-four hours. It was then decomposed in iced sodium carbonate and extracted with ether. Upon distillation yellow oils were obtained

---

[8] The phosphorus oxychloride does not interfere in these reactions (see Ref. 7).

[9] This does not necessarily mean that the acid chloride is not of the normal type, however, since the Friedel and Crafts reactions on *trans*-trimethylbenzoylacrylyl chloride and the corresponding monomethyl derivative[2] give only very small yields of the diketones.

which partly crystallized to give a total of 4.4 g. (41%) of nearly pure ester; cryst. from alcohol; m. p. 83° (corr.).

Anal. Calcd. for $C_{16}H_{20}O_3$: C, 73.80; H, 7.74. Found: C, 73.52; H, 7.49.

One gram of ester in 15 cc. of alcoholic sodium hydroxide (one equiv.) was hydrolyzed completely in forty-eight hours. The product (0.35 g., 37%) was isolated in the usual way and identified as the original acid.

Trans-2-(2,4,6-trimethylbenzoyl)-1,2-dimethylacrylic Ethyl Ester, $(CH_3)_3C_6H_2COC(CH_3){=}C(CH_3)COOC_2H_5$.—Prepared by adding 10 g. of dimethylfumaric monoethyl ester mono-acid chloride to a well-stirred suspension of 9.5 g. of aluminum chloride in 50 cc. of carbon disulfide and 8.5 g. of mesitylene. The red reaction mass was heated for one hour at 40–45° and decomposed in ice and hydrochloric acid in the usual way. The carbon disulfide solution was dried over sodium carbonate, evaporated, and the oily residue distilled under reduced pressure; 7.9 g. of pale yellow oil (55%) was obtained; b. p. 131–133° (corr.) at 2 mm.

Anal. Calcd. for $C_{17}H_{22}O_3$: C, 74.40; H, 8.09. Found: C, 74.04; H, 8.10.

One gram of the ester was hydrolyzed by standing in 60% alcoholic sodium hydroxide (one equiv.). On diluting the solution with water and extracting with ether the non-acidic by-products were removed. From the aqueous solution on acidification and extraction with ether, an oil was obtained which partly solidified, giving a yield of 0.3 g. (22%) of nearly pure trimethylbenzoyldimethylacrylic acid.

Dimethyl Unsaturated 1,4-Diketones

Trans-2,3-dibenzoylbutene-2 (Dibenzoyldimethylethylene) (XV).—Dimethylfumaryl chloride (25 g.) was added over a period of half an hour to a well-stirred suspension of 41.5 g. of anhydrous, finely ground aluminum chloride in 200 cc. of dry benzene. The cream colored mixture was stirred with heating on a steam-bath for twenty minutes and the viscous mass hydrolyzed in ice and hydrochloric acid. Upon concentrating the benzene layer successive crops of nearly pure diketone were obtained; yield 31 g. (85%); cryst. from benzene; sol. in chloroform, diff. sol. in ethanol; m. p. 139.5° (corr.).

Anal. Calcd. for $C_{18}H_{16}O_2$: C, 81.78; H, 6.10. Found: C, 81.51; H, 6.05.

Samples exposed to direct sunlight in absolute alcohol, benzene, acetone, and ethyl acetate gave only unchanged material and non-crystalline by-products. From benzene a small amount of an unidentified substance was isolated (m. p. 175°). From absolute ethanol a small yield (about 10%) of a colorless solid of m. p. 103° was isolated (*Anal.* C, 78.15, 78.25; H, 7.76, 7.68).

Short refluxing of the diketone with sodium methylate solution gave resinous products.

Solutions of the diketone in acetic acid or chloroform reacted slowly in the sunlight with bromine, liberating hydrogen bromide and giving resinous products.

The diketone dissolved quickly in 40% hydrogen bromide in acetic acid, and a new product containing halogen appeared as colorless needle crystals of m. p. 113° (corr.). The new substance appears not to be a simple addition compound since refluxing for four hours in alcohol with potassium acetate produced no change.

2,5-Diphenyl-3,4-dimethylfuran (XIX).—A well-stirred solution of 2 g. of *trans*-dibenzoyldimethylethylene in 50 cc. of hot glacial acetic acid was treated with 5 g. of zinc dust, and the mixture heated with stirring for twenty minutes. The solution was filtered, cooled, and diluted with water. The oil which precipitated crystallized on standing and was filtered off; yield 1.8 g. Fractional crystallization from alcohol gave the less soluble furan in a yield of 0.62 g. (33%). (The rest of the solid product, probably consisting of a mixture of the two theoretically possible ethanes, will be investigated later.) It was crystallized from ethanol; m. p 116° (corr.).

Anal. Calcd. for $C_{18}H_{16}O$: C, 87.05; H, 6.50. Found: C, 87.05, 86.63; H, 6.78, 6.55.

Trans-2,3-di-[2,4,6-trimethylbenzoyl]-butene-2 (Di-[trimethylbenzoyl)-dimethylethylene] (XV).—Dimethylfumaryl chloride (25 g.) was added to a well-stirred mixture of 41.5 g. of anhydrous aluminum chloride and 34 g. of mesitylene in 200 cc. of carbon disulfide over a period of one hour and the mixture then heated for two hours on a steam-bath, and hydrolyzed in the usual way. The carbon disulfide solution on evaporation gave successive crops of nearly colorless diketone in a yield of 41.9 g. (87%) as cream tinted crystals melting to a yellow liquid; cryst. from benzene as rhombic plates; m. p. 174.5° (corr.); sol. in chloroform; slightly sol. in alcohol.

Anal. Calcd. for $C_{24}H_{18}O_2$: C, 82.71; H, 8.10. Found: C, 82.65; H, 8.06.

On standing in 40% hydrobromic acid in acetic acid a colorless, viscous, oily, insoluble addition product separated.

Cis-2,3-di-[2,4,6-trimethylbenzoyl]-butene-2 (Di-[trimethylbenzoyl)-dimethylethylene] (XVI).—A solution of 5 g. of the *trans* isomer in 50 cc. of benzene was exposed to direct sunlight for two weeks. The oily product was separated by a laborious series of fractional crystallizations from alcohol into an oil, unchanged material, and 2 g. of the *cis* isomer which was recrystallized from alcohol as elongated flat plates; m. p. 149° (corr.).

Anal. Calcd. for $C_{24}H_{28}O_2$: C, 82.71; H, 8.10. Found: C, 82.40; H, 8.18.

The *cis* isomer proved to be stable when exposed to sunlight in benzene with a trace of iodine, and was recovered with slightly lowered melting point.

When warmed with aluminum chloride in carbon disulfide or benzene, the mixture turned black, and on hydrolysis only resinous products were obtained.

2,5-Dimesityl-3,4-dimethylfuran (XIX).—*Trans*-di-[trimethylbenzoyl]-dimethylethylene (2 g.) was reduced by heating in acetic acid for fifteen minutes with zinc dust. The product was isolated by filtering and diluting with water. The crystalline precipitate was extracted with ether. Upon concentrating, the ether solution deposited 0.18 g. of di-[trimethylbenzoyl]-butane (see below). The solution was then allowed to evaporate to dryness in a glass dish. The bulk of the product (the furan) crawled up the sides and crystallized, leaving a small powdery deposit on the bottom which was easily scraped out and separated from the bulk of material. This latter deposit was digested with a small amount of ether and gave 0.1 g. of the ether-insoluble di-[trimethylbenzoyl]-butane. The ether soluble furan, 1.5 g. (80%) was recrystallized from alcohol, in which it is moderately soluble hot as large thin diamond-shaped plates; m. p. 144° (corr.).

Anal. Calcd. for $C_{24}H_{28}O$: C, 86.72; H, 8.49. Found: C, 86.88; H, 8.75.

In a similar reduction of 0.05 g. of the *cis* diketone, using the same procedure for working up the products, 0.004 g. (8%) of di-[trimethylbenzoyl]-butane and 0.043 (90%) g. of dimesityldimethylfuran were isolated nearly pure and identified by mixed melting points. These percentages are practically the same as the crude yields from the reduction of the *trans* isomer. If the yield of the crude furan in this case were corrected for the small amount of the di-[trimethylbenzoyl]-butane present, the yields of pure products would coincide also.

2,3-Di-(2,4,6-trimethylbenzoyl)-butane (XVIII).—The ether-insoluble fraction from the above reduction of the *trans* diketone (0.28 g., 15%) was difficultly soluble in hot alcohol from which it crystallized as thin diamond-shaped plates of m. p. 191.5–192° (corr.).

Anal. Calcd. for $C_{24}H_{80}O_2$: C, 82.23; H, 8.63. Found: C, 82.45; H, 8.70.

A small sample of the pure product was refluxed in acetic acid with zinc dust for fifteen minutes and was recovered unchanged; 0.035 g. was treated with acetic anhydride and a droplet of sulfuric acid on the end of a glass rod. The difficultly soluble diketone dissolved immediately and new crystals appeared. The mixture was warmed to bring everything into solution and then cooled, allowed to crystallize, and filtered; yield 0.02 g. of nearly pure dimesityldimethylfuran of m. p. 134–140°; identified by recrystallization and mixed melting point.

Summary

The synthesis and preliminary study of *cis* and *trans* benzoyldimethylacrylic acids is reported. The inversion of the *trans* isomer to the *cis* under the influence of alkali is discussed.

Diaroyl-dimethylethylenes have been synthesized from dimethylfumaryl chloride.

The 1,6-addition of hydrogen to *cis* and *trans* di-trimethylbenzoyldimethylethylene is discussed.

UNIVERSITY, VIRGINIA

RECEIVED SEPTEMBER 8, 1932
PUBLISHED APRIL 6, 1933

[CONTRIBUTION FROM THE UNIVERSITY OF COLORADO]

The Effect of Strong Ultraviolet Irradiation upon the Toxicity of Pure Nicotine

BY GLEN WAKEHAM AND CLARENCE B. JOHNSTON

Two years ago A. J. Pacini and Hugh McGuigan[1] reported that the toxic action of nicotine upon frogs was destroyed by ultraviolet irradiation. Some time later, George P. Tracy, working with the senior author of the present paper (G. W.), demonstrated that while the toxic effects of nicotine upon albino rats can be considerably diminished by ultraviolet irradiation they are by no means destroyed.[2] At the same time it was shown that irradiation beyond the optimum time of exposure will almost completely restore the original toxicity of the nicotine. The work recorded in the present paper is an attempt to ascertain whether any reasonable amount of ultraviolet irradiation will destroy the toxic effects of nicotine upon albino rats.

Experimental

The source of irradiation used was a carbon arc for which the makers claim an intensity in the ultraviolet region forty times that of the ordinary mercury vapor lamp. This claim was approximately verified. In the work earlier reported[2] an irradiation of seventy-five minutes was required, under the mercury vapor lamp, at a distance of ten centimeters, to produce the maximum detoxication. At a distance of fifteen centimeters from the carbon arc the maximum detoxication effects were obtained by irradiation periods of three or four minutes.

In the first series of experiments here recorded, pure, freshly redistilled nicotine was irradiated, in quartz-glass tubes, at a distance of fifteen centimeters from the arc, for periods of from one to sixty minutes. The layer of nicotine (water-clear) was about

---

(1) Pacini and McGuigan, *J. Pharmacol.*, **33**, 241 (1930).

(2) Wakeham and Tracy, *ibid.*, **44**, 295 (1932).