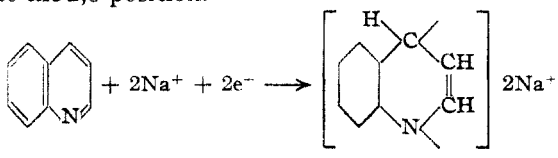
vestigation, however, suggests that 1,4-addition is more probable. It is assumed that reduction by sodium involves salt formation at the 1,4-positions, accompanied by a shift of the double bond to the 2,3-position.



The intensely red colored ammonia solutions indicate the formation of sodium salts,[9] the stability of which is shown by their reactions with ethyl bromide and the fact that they are not readily ammonolyzed.[10] Addition of ammonium bromide would, of course, produce 1,4-dihydroquinoline, sodium bromide and ammonia. The above view is also supported by the fact that, even in the presence of a considerable excess of sodium, reduction does not proceed beyond the extent indicated above. If reduction should occur initially at the 1,2-position, the double bond in the heterocyclic ring would remain conjugated with the unsaturation in the aromatic ring and reduction should be expected to continue.[1] It is generally accepted[11] that an isolated double bond such as that proposed above would not be susceptible to reduction under the conditions employed in the present work. By analogy, it may be assumed that reduction by hydrogen must involve a similar mechanism since the extent of reduction is the same in both cases.

(9) Hückel and Bretschneider, *Ann.*, **540**, 157 (1939).

(10) *Cf.* Wooster and Smith, THIS JOURNAL, **53**, 179 (1931).

Summary

1. The reduction of quinoline to dihydroquinoline, 5-amino- and 5-nitroquinolines to dihydro-5-aminoquinoline, and 8-amino- and 8-nitroquinolines to dihydro-8-aminoquinoline by sodium in liquid ammonia at −33.5° or by hydrogen generated by addition of sodium to liquid ammonia solutions of ammonium bromide at the same temperature, has been described.

2. Evidence has been presented in support of the view that reduction of the heterocyclic ring occurs at the 1,4-positions.

3. Although the extent of reduction is substantially the same in both cases, reduction by sodium is generally more rapid and more complete than reduction by hydrogen.

(11) Campbell and Campbell, *Chem. Rev.*, **31**, 82 (1942).

AUSTIN, TEXAS RECEIVED OCTOBER 23, 1942

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY OF HOWARD UNIVERSITY]

2,4,6-Trimethylbenzylphenylglyoxal

BY R. PERCY BARNES AND ROBERT J. BROWN[1]

By substituting one of the alpha hydrogens in phenylbenzylglyoxal[2] by the phenyl group, the resulting benzhydryl phenyl diketone[3] shows a chemical behavior which is quite different from the parent substance.

We have already reported the chemical behavior of mesitylbenzylglyoxal.[4] The purpose of this paper is to show the preparation and properties of the isomeric alpha diketone 2,4,6-trimethylbenzylphenylglyoxal (II).

2,4,6-Trimethylbenzalacetophenone was oxidized to α-benzoyl-β-mesityl ethylene oxide (I), which in turn was isomerized to 2,4,6-trimethylbenzylglyoxal (II). This diketone is a low-melting yellow solid, producing no color with alcoholic ferric chloride, and giving negative results when titrated by the Kurt Meyer method. There is no doubt as to the structure of this diketone, for it is cleaved smoothly by alkaline hydrogen peroxide to mesitylacetic and benzoic acids. Thus the effect of the mesityl nucleus in this position is to make this diketone completely ketonic, thus causing it to resemble benzhydrylphenyldiketone much more closely than it does its isomeric alpha diketone. The mesityl nucleus does not affect the carbonyl groups, for 2,4,6-trimethylbenzyl phenyl diketone reacts with *o*-phenylenediamine, yielding a quinoxaline (III).

2,4,6-Trimethylbenzyl phenyl diketone further resembles benzhydryl phenyl diketone and differs from mesitylbenzylglyoxal in that it resists attempts to substitute alpha hydrogens by bromine.

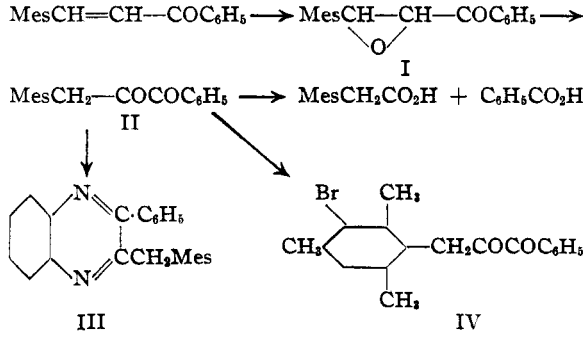
(1) In partial fulfillment of the requirements for the Master's Degree.

(2) Kohler and Barnes, THIS JOURNAL, **56**, 211 (1934).

(3) Kohler and Weiner, *ibid.*, **56**, 434 (1934).

(4) R. P. Barnes, *ibid.*, **57**, 937 (1935).

The mesityl nucleus in this position, however, seems to possess nuclear hydrogens which are more reactive than those in the isomeric mesitylbenzylglyoxal or even its own alpha hydrogens, for all attempts to substitute an alpha hydrogen by bromine end in a quantitative nuclear monobromination product (IV).



The 2,4,6-trimethyl-3-bromobenzylphenyl diketone (IV) is cleaved by alkaline hydrogen peroxide to 2,4,6-trimethyl-3-bromobenzoic and benzoic acids. It also forms a quinoxaline (V). This diketone is recovered unchanged when refluxed with potassium acetate and acetic acid, but is acetylated quantitatively when refluxed with potassium acetate and acetic anhydride, producing the acetate of the enolic modification of the alpha diketone (VI). This acetate yields the quinoxaline (V). The acetate (VI) is hydrolyzed by cold concd. sulfuric acid to the enol (VII), which enol is acetylated by both acetyl chloride and potassium acetate–acetic anhydride. Cold concd. sulfuric acid converts the diketone (IV) into the enol (VII), and boiling alcohol ketonizes the enol to (IV). The enol also gives the quinoxaline (V). The enol is cleaved by alkaline hydrogen peroxide to benzoic and 2,4,6-trimethyl-3-bromobenzoic acids.

The acetate (VI) when treated with the calculated amount of bromine was recovered unchanged. The enol (VII) is 100% enolic in methanol and is brominated to a golden yellow oil (VIII) in either methanol or absolute ether.

Experimental

α-Benzoyl-β-mesitylethylene Oxide (I).—To a hot solution of 11.5 g. of 2,4,6-trimethylbenzalacetophenone in 150 cc. of hot methanol was added, with cooling and rapid stirring, 7 g. of superoxol. The solution was made alkaline by the slow addition of saturated aqueous sodium hydroxide, and stirring was continued for twenty minutes. At the end of this period colorless crystals were separating. The alcoholic solution was diluted with one-fourth of its volume of water and stirred for fifteen minutes longer. On chilling, a colorless crystalline solid separated. The yield was 10 g. or 80% of the calculated, melting at 73°.

Anal. Calcd. for $C_{18}H_{18}O_2$: C, 81.2; H, 6.8. Found: C, 81.1; H, 7.2.

This oxide could not be made according to Widman's method,[5] using mesitylaldehyde and ω-bromoacetophenone. Each attempt resulted in a small yield of a colorless, needle-like solid, containing bromine, and melting at 137°.

2,4,6-Trimethylbenzylphenylglyoxal (II).—To a solution of 32.7 g. of α-benzoyl-β-mesitylethylene oxide in 300 cc. of hot methanol was added dropwise, with heating and stirring, a saturated aqueous solution of 18.8 g. of sodium hydroxide. The solution turned a deep orange color. The solution was boiled for five minutes, cooled to room temperature, and acidified with concd. hydrochloric acid. It was then diluted to about three times its volume with water, and extracted with ether. The ethereal extract was washed with sodium bicarbonate solution, and finally with water. It was dried over anhydrous sodium sulfate and then evaporated to dryness. The resulting yellow solid

(5) Widman, *Ber.*, **49**, 477 (1916).

was recrystallized from methanol as a feathery canary yellow substance, melting at 55°. The yield was 27.5 g.

Anal. Calcd. for $C_{18}H_{18}O_2$: C, 81.2; H, 6.8. Found: C, 81.0; H, 6.9.

This diketone gives no color with alcoholic ferric chloride, and Kurt Meyer titrations indicate that it is completely ketonic in alcoholic solution.

2,4,6-Trimethylbenzylphenylquinoxaline (III).—A solution of 5 g. of the diketone and 5 g. of *o*-phenylenediamine in 150 cc. of methanol was refluxed gently for one hour, after which it was allowed to cool to room temperature and diluted with 250 cc. of water, and extracted with ether. The ethereal solution was washed free of excess *o*-phenylenediamine with dilute hydrochloric acid (1:3). The ether was evaporated, and the resulting colorless solid was crystallized from methanol. A yield of 5 g. (80% of the theoretical) of fine colorless needles, melting at 118°, was obtained.

Anal. Calcd. for $C_{24}H_{22}N_2$: C, 85.2; H, 6.5. Found: C, 85.0; H, 6.4.

Cleavage of Diketone.—To a canary yellow solution of 0.3 g. of the diketone in 25 cc. of hot methanol was added an excess of superoxol. The solution was made alkaline with saturated aqueous sodium hydroxide, whereupon the solution became colorless instantaneously. The solution was cooled and acidified with concd. hydrochloric acid. A colorless solid, melting from 117–157°, was obtained. By fractional crystallization benzoic and 2,4,6-trimethylphenylacetic acids, melting at 120° and 165°, respectively, were isolated and identified by mix-melting with authentic samples.

2,4,6-Trimethyl-3-bromobenzylphenyl Diketone (IV).—To a solution of 10 g. of the α-diketone in 30 cc. of chloroform was added dropwise, with constant shaking, a solution of 6.1 g. of bromine in 10 cc. of chloroform. Each drop of bromine was rapidly decolorized at first, and copious fumes of hydrogen bromide were evolved. At the end of the addition, the solution was a cherry red in color, which gradually faded to a pale yellow, as shaking continued. The chloroform was pumped off, and the resulting golden yellow oil taken up in hot methanol. A yield of 11.5 g. of yellow solid was obtained, which upon recrystallization from methanol, melted at 72°, and did not liberate iodine from potassium iodide–acetone solution.

Anal. Calcd. for $C_{18}H_{17}O_2Br$: C, 62.6; H, 4.9. Found: C, 62.4; H, 5.1.

2,4,6-Trimethylphenyl-3-bromobenzylphenylquinoxaline (V).—This quinoxaline was prepared as indicated above, yielding a yellow crystalline solid, melting at 161°. *Anal.* Calcd. for $C_{24}H_{21}N_2Br$: C, 69.1; H, 5.0. Found: C, 69.0; H, 5.0.

Cleavage of the Bromo-diketone.—This diketone was cleaved as indicated above. The mixed acids resulting melted from 140–160°, with softening about 116°. Sublimation of the mixed acids yielded feathery crystals of benzoic acid, identified by its m. p. and mixed m. p. Recrystallization of a portion of the mixed acids yielded a colorless crystalline solid, melting at 168°, identified as 2,4,6-trimethyl-3-bromobenzoic acid.[6]

(6) P. R. Shildneck and Roger Adams, THIS JOURNAL, **53**, 349 (1931).

The Acetate of 2,4,6-Trimethyl-3-bromobenzylphenylglyoxal (VI).—A solution of 15 g. of the bromoketone in 100 cc. of acetic anhydride was refluxed for thirty minutes with 15 g. of freshly fused potassium acetate. The solution turned from yellow to almost colorless. Potassium bromide separated. When cold the contents of the flask were poured into a large volume of cold water. A solid separated. It was filtered and washed with water, finally dissolved in hot methanol and filtered, from which solution, colorless crystals, melting at 107°, separated. The crude yield was 14.5 g.

Anal. Calcd. for $C_{20}H_{19}O_3Br$: C, 62.0; H, 4.9. Found: C, 61.6; H, 5.0.

This acetate gives no color with alcoholic ferric chloride.

The bromoketone when refluxed for one hour with glacial acetic acid and potassium acetate, is recovered unchanged.

In like manner the acetate is recovered unchanged when dissolved in chloroform and treated with the calculated amount of bromine.

The Enol of 2,4,6-Trimethyl-3-bromobenzylphenylglyoxal (VII).—Two grams of the acetate was dissolved in 40 cc. of cold concd. sulfuric acid, producing a blood red solution. The solution was poured, with rapid stirring, over finely crushed ice. Each drop of the solution solidified to a tan-colored solid as it came in contact with the ice. The mixture was stirred until the ice had melted, and was then filtered and washed. The crude product was recrystallized from methanol in which it is sparingly soluble, giving very light tan-colored crystals melting at 147°.

Anal. Calcd. for $C_{18}H_{17}O_2Br$: C, 62.6; H, 4.9. Found: C, 62.5; H, 5.0.

This enol produces a greenish-brown coloration with alcoholic ferric chloride. It is acetylated by acetyl chloride and by acetic anhydride and potassium acetate to the 107°-melting acetate. It is also cleaved by alkaline hydrogen peroxide to benzoic and 2,4,6-trimethyl-3-bromobenzoic acids. It yields the same quinoxaline as given by the ketonic modification.

Interconversion of (IV) and (VI).—One gram of the enol was dissolved in 30 cc. of alcohol, boiled for ten minutes, and chilled. A small amount of the starting material, melting at 147°, was obtained. The mother liquor was concentrated and chilled, whereupon a copious lemon yellow precipitate was formed. This substance melted and mix-melted with the original bromoketone at 72°.

One and one-half grams of the bromoketone was dissolved in 20 cc. of cold concd. sulfuric acid. The solution was blood red in color. It was poured over finely crushed ice, producing a tan-colored solid. The solid was filtered, washed, dried and crystallized from methanol, yielding light tan crystals melting and mix-melting with the enol at 147°.

Bromination of the Enol.—Three grams of the enol was dissolved in 50 cc. of absolute ether, and to this practically colorless solution 1.3 g. of bromine was added dropwise. Each drop of bromine was instantaneously decolorized with the final production of a yellow ethereal solution. The bromination product could not be obtained in the solid state from ether, alcohol or petroleum ether. It was obtained finally as a golden yellow oil.

Anal. Calcd. for $C_{18}H_{16}O_2Br_2$: C, 50.9; H, 3.8. Found: C, 50.7; H, 4.0.

This oil liberates iodine from potassium iodide-acetone solution, yielding the ketonic modification of the bromo diketone, melting at 72°.

Summary

In this paper are reported the preparation and many of the chemical properties of the α-diketone, 2,4,6-trimethylbenzylphenylglyoxal.

WASHINGTON, D. C. RECEIVED NOVEMBER 9, 1942

[CONTRIBUTION FROM THE LABORATORY OF PHYSIOLOGICAL CHEMISTRY OF THE OHIO STATE UNIVERSITY]

Studies on the Chemistry of the Fatty Acids. XII. The Preparation of Alpha- and Beta-Linoleic Acids by Debromination in Various Solvents and Observations on the Chemistry of These Acids

BY JEROME S. FRANKEL[1] AND J. B. BROWN

In a previous report from this Laboratory, it was shown that α-linoleic acid[2] which is prepared by debromination of pure, petroleum ether–insoluble tetrabromostearic acid is a mixture of isomeric acids.[5] The principal component amounting to about 88% of the mixture, is an acid of high tetrabromide number (Tb. N. 102.9); it is believed to be the *cis–cis* modification of 9,12-octadecadienoic acid. The lesser component is believed to be either the *cis–trans* or *trans–cis* modification of this dienoic acid, or a mixture of acids none of which yields the usual insoluble bromide. It seems probable that these isomers of linoleic acid were formed by isomerization during the debromination reaction. These conclusions concerning α-linoleic acid were based mainly on one preparation of the acid, carried out in methyl alcohol to which was added only small amounts of hydrochloric acid to promote the debromination, and also on other experience in this Laboratory.

One of the objectives of the present work was to try the effect of debromination solvent on the composition of the resultant alpha-acid. In addition to methyl alcohol and pyridine, which have been used as debromination solvents by previous workers, four new solvents were tried, namely, ether, isopropyl ether, dioxane and glacial acetic acid. The first three of these gave excellent results and were found to be much more convenient than either methyl alcohol or pyridine. When methyl alcohol is used, there are always formed variable amounts of esters which must be removed. With pyridine, this difficulty is not encountered, but there is always some trouble in removing the pyridine. Ether, isopropyl ether and dioxane are neutral solvents and, after the debromination reaction, it is only necessary to wash out the last traces of zinc bromide, to remove the solvent and to distill the product. Yields with these solvents were comparable to usual experience with methyl alcohol debrominations. Yields were slightly lower when pyridine was used, but the product was satisfactory. Debromination in glacial acetic acid gave a product of low iodine value and tetrabromide number. Incidentally, attempts to debrominate in petroleum ether were without success. Although, except in the case of acetic acid, the iodine values of the several products described in detail in Table I are practically the theoretical for 9,12-octadecadienoic acid the tetrabromide numbers varied from 81.3 to 102.4, indicating linoleic acid (*cis–cis* 9,12-octadecadienoic) contents of 81–99%, along with one to nineteen per cent. of isomeric acids. It is of special interest to note that one of the preparations in pyridine gave almost the same tetrabromide number, 102.4, as that obtained for the pure acid[5] (102.9), although the melting point was still 2° low. These results verify our previous con-

(1) Presented in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Graduate School, The Ohio State University.

(2) The following nomenclature is used in this paper: *linoleic acid, cis–cis*, 9,12-octadecadienoic acid, the principal naturally occurring acid of this series; *α-linoleic acid*, the mixture of octadecadienoic acids resulting from debromination of the 114–115° melting tetrabromides; *β-linoleic acid*, the product of debromination of the liquid tetrabromides, which result from bromination of α-linoleic acid or linoleic acid; *crystallization linoleic acid*, the product obtained by applying the method of Frankel and Brown to the fatty acids of semi-drying oils. This acid is ninety-five to one hundred per cent. linoleic acid[3,4] *isomeric linoleic acids or isomeric octadecadienoic acids.* These may be the *trans–cis* or the *cis–trans* 9,12-octadecadienoic acids, but not the *trans–trans* modification, since the acids in question give only liquid tetrabromides. In a general sense, other isomers with double bonds in other than the 9–12 position, but with theoretical iodine values, are not precluded.

(3) Frankel and Brown, THIS JOURNAL, **63**, 1483 (1941).

(4) Frankel, Stoneburner and Brown, *ibid.*, **65**, 259 (1943).

(5) Matthews, Brode and Brown, THIS JOURNAL, **63**, 1064 (1941).