Summary

1. 1,5-Diacetoxynaphthalene suspended in carbon tetrachloride yields with chlorine in the sunlight or with iodine as a catalyst a dichloro substitution product and at 80° a trichloro product.

2. The chloro compounds yield the same quinone when oxidized with chromic acid.

3. The quinone gave mono, di and trihydroxy naphthols.

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The Reaction between Alpha, Beta-Unsaturated Ketones and Organic Magnesium Compounds. Unsaturated Mesitylenic Ketones

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Earlier papers on this subject contain a description of the reaction between organic magnesium compounds and every member of the series of alpha, beta-unsaturated ketones which could be formed by replacing the hydrogen atoms in acrolein one by one with phenyl groups. Not one of these ketones under any conditions formed a product containing more than two phenyl groups in the beta position. In the case of tetraphenyl propenone, from which such a product was most to be expected, the reaction took an entirely unexpected direction involving addition to a phenyl group.[1]

$$(C_6H_5)_2C{=}C(C_6H_5)COC_6H_5 + C_6H_5MgBr \longrightarrow (C_6H_5)_2C{=}C(C_6H_5)COC_6H_4C_6H_5(o)$$

In view of this result it now became a matter of interest to study the reaction with unsaturated mesitylenic ketones which are so constituted that the hindrance to 1,2 addition would be prohibitive, and that any type of 1,4 addition would inevitably lead to substances with three hydrocarbon residues in the β-position. With this end in view we decided to investigate the behavior of beta phenyl benzalacetomesitylene. The reaction between phenylmagnesium bromide and this ketone had been briefly examined many years ago with negative results,[2] but with the experience gained since then in working with highly phenylated compounds this outcome no longer seemed inevitable.

We have now found that by operating under favorable conditions and with sufficient persistence it is possible to add both phenylmagnesium bromide and ethylmagnesium bromide to this ketone in ether. In the case of methylmagnesium iodide the highly colored intermediate complex product is so nearly insoluble in ether that a reaction in this solvent is impossible but even here it is possible to secure reaction by operating at a

(1) Kohler and Nygaard, THIS JOURNAL, **52**, 4128 (1930).

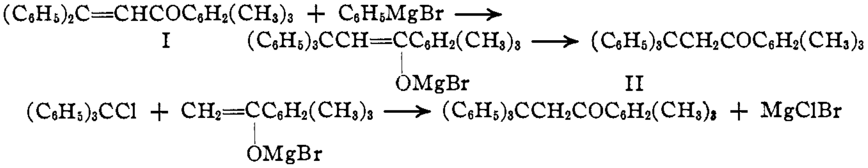
(2) Kohler, *Am. Chem. J.*, **38**, 560 (1907).

higher temperature in benzene. In all three cases the products are saturated ketones.

These highly substituted saturated ketones are exceedingly unreactive; most reagents that attack them at all degrade them to the point where the results are no longer significant. Their structure therefore had to be established by independent syntheses. An attempt to synthesize the product that had been obtained with phenylmagnesium bromide by a Friedel and Crafts reaction was balked at the outset by the ease with which triphenyl propionyl chloride was converted into an indene derivative. Another attempt to synthesize it by the interaction of sodium triphenyl methane and α-chloro acetomesitylene in liquid ammonia was equally unsuccessful, the ketone merely exchanging one of its hydrogen atoms for sodium

$$(C_6H_5)_3CNa + ClCH_2COC_6H_2(CH_3)_3 \longrightarrow (C_6H_5)_3CH + ClCH{=}C(ONa)C_6H_2(CH_3)_3$$

The synthesis of the saturated ketone was, however, readily accomplished by taking advantage of the fact that when acetomesitylene is treated with a Grignard reagent it forms a halomagnesium enolate which reacts essentially like the metallic derivatives of acetoacetic ester.[3] Under proper conditions this enolate reacted with triphenylmethyl chloride to form the same substance that was obtained by the action of phenylmagnesium bromide on the unsaturated ketone



$$\underset{\text{I}}{(C_6H_5)_2C{=}CHCOC_6H_2(CH_3)_3} + C_6H_5MgBr \longrightarrow (C_6H_5)_3CCH{=}\underset{\displaystyle OMgBr}{C}C_6H_2(CH_3)_3 \longrightarrow \underset{\text{II}}{(C_6H_5)_3CCH_2COC_6H_2(CH_3)_3}$$

$$(C_6H_5)_3CCl + CH_2{=}\underset{\displaystyle OMgBr}{C}C_6H_2(CH_3)_3 \longrightarrow (C_6H_5)_3CCH_2COC_6H_2(CH_3)_3 + MgClBr$$

Owing to the difficulty of preparing pure methyl diphenyl chloro methane this device could not be used for establishing the structure of the product obtained with methylmagnesium iodide, but equally conclusive evidence was secured in a different manner. By analogy with the reaction of phenylmagnesium bromide, methylmagnesium iodide would be expected to form methyl diphenyl propionyl mesitylene and this same ketone should be formed by the action of phenylmagnesium bromide on β-methyl benzalacetomesitylene. This was found to be the case.

A. $$\underset{\text{I}}{(C_6H_5)_2C{=}CHCOC_6H_2(CH_3)_3} + CH_3MgI \longrightarrow$$
$$(C_6H_5)_2(CH_3)CCH{=}C(OMgI)C_6H_2(CH_3)_3 \longrightarrow \underset{\text{III}}{(C_6H_5)_2(CH_3)CCH_2COC_6H_2(CH_3)_3}$$

B. $$\underset{\text{IV}}{(C_6H_5)(CH_3)C{=}CHCOC_6H_2(CH_3)_3} + C_6H_5MgBr \longrightarrow$$
$$(C_6H_5)_2(CH_3)CCH{=}C(OMgBr)\,C_6H_2(CH_3)_3 \longrightarrow \underset{\text{III}}{(C_6H_5)_2(CH_3)CCH_2COC_6H_2(CH_3)_3}$$

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[3] Kohler and Baltzly, THIS JOURNAL, 54, 4015 (1932).

These results show that, though difficult, it is not impossible to add Grignard reagents to β-phenyl benzalacetomesitylene and analogous compounds—the hydrocarbon residues as usual going into the beta position. The difference in the speed with which the several addition reactions occur is surprising. Thus, although the two reactions represented by A and B result in the formation of the same magnesium derivative, the first requires for completion at least three hours at the boiling point of benzene, while the second proceeds almost as fast as the reactants are brought together at the ordinary temperature. This great difference in rate appears to be due largely to a difference in the quality of the conjugated system, because methylmagnesium iodide can be substituted for phenylmagnesium bromide in the second reaction without materially altering its speed.

$$CH_3C(C_6H_5){=}CHCOC_6H_2(CH_3)_3 + CH_3MgI \longrightarrow$$
$$(CH_3)_2C(C_6H_5)CH{=}C(OMgI)C_6H_2(CH_3)_3 \longrightarrow (CH_3)_2C(C_6H_5)CH_2COC_6H_2(CH_3)_3$$

Experimental Part

β-Phenyl benzalacetomesitylene has been obtained heretofore by means of a series of reactions that are not well adapted for making larger quantities of the substance. We therefore devised a new method of preparation which is modeled after the best method for obtaining β-phenyl benzalacetophenone and which is indicated by the following series of compounds

$$\underset{A}{C_6H_5CH{=}CHCOC_6H_2(CH_3)_3} \longrightarrow \underset{B}{C_6H_5CHBrCHBrCOC_6H_2(CH_3)_3} \longrightarrow$$
$$\underset{C}{C_6H_5COCH_2COC_6H_2(CH_3)_3} \longrightarrow \underset{D}{(C_6H_5)_2COHCH_2COC_6H_2(CH_3)_3} \longrightarrow$$
$$\underset{I}{(C_6H_5)_2C{=}CHCOC_6H_2(CH_3)_3}$$

Benzalacetomesitylene, the first substance in the series, was originally prepared by the action of cinnamoyl chloride on mesitylene. It is much more easily obtained in quantity by the usual condensation of an aldehyde with a methyl ketone. Our procedure was as follows.

To a solution of 62 g. of sodium hydroxide in 540 cc. of water, and 270 g. of alcohol was added, first 200 g. of acetomesitylene and then, gradually, with vigorous stirring, 146 g. of freshly distilled benzaldehyde. After stirring for six hours the mixture was cooled with ice and salt and inoculated, the stirring being continued to produce small crystals. The mixture crystallized rapidly and completely. The solid was washed with water until free from base and then with 25% alcohol to remove organic impurities. The yield of crude dry product was 290 g. or 94%. The crude product is sufficiently pure for the next step.

From the unsaturated ketone the dibromide (B) was obtained in the usual manner. In working with large quantities of material it is essential that the bromine be added slowly and with vigorous stirring, and also that it be not added in excess, otherwise some of it enters the mesitylene group and it is impossible to get bromine-free products in subsequent operations. From 290 g. of crude unsaturated ketone we obtained 357 g. of pure recrystallized product melting at 126–127°—a yield of 76%.

In a flask provided with a stirrer, a reflux condenser and a dropping funnel, 357 g. of the pure dibromide was mixed with 250 cc. of dry methyl alcohol. From the dropping funnel a solution of 39 g. of sodium in 380 cc. of dry methyl alcohol was added gradually while the flask was cooled with running water, the stirrer being started as soon as the mixture became sufficiently fluid. After all the methylate had been added, the mixture was boiled for three hours, then diluted with enough water to dissolve the sodium bromide and acidified with hydrochloric acid. The acidified solution was boiled for three hours, then cooled in ice water while it was stirred vigorously to prevent the formation of large lumps. It deposited a solid which after washing with water and with 50% alcohol yielded 219 g. of crude dry product. On recrystallization from methyl alcohol 20–30% of the material was left in the filtrates, the yield of pure product being 70–80%.

Anal. Calcd. for $C_{18}H_{81}O_2$: C, 81.2; H, 6.8. Found: C, 80.9; H, 6.8.

Benzoylacetomesitylene (C) is moderately soluble in all common organic solvents except petroleum ether in which it dissolves but sparingly. It crystallizes in colorless prisms and melts at 79°. A bromine titration by the Kurt Meyer method showed that like other aromatic diketones it is completely enolic, and in a quantitative examination with methylmagnesium iodide it reacted with two moles of reagent and liberated one mole of gas.

The diketone was converted into the β-hydroxy ketone (D) in the following manner. A solution of 50 g. of the substance in dry ether was added gradually to a similar solution of phenylmagnesium bromide. The mixture was boiled until the purple-red color which developed in the solution disappeared—usually five to six hours. At this stage the solution contained a dimagnesium compound which is stable but in order to isolate the carbinol, which readily loses water, it was necessary to proceed with great caution. The mixture was added slowly with efficient stirring to ice and hydrochloric acid, the ethereal layer washed with sodium carbonate, dried and allowed to evaporate spontaneously. It left a yellow oil which solidified when its solution in methyl alcohol was cooled in a freezing mixture. The solid was purified by recrystallization from methyl alcohol.

Anal. Calcd. for $C_{24}H_{24}O_2$: C, 83.7; H, 7.0. Found: C, 83.6; H, 7.2.

The carbinol is moderately soluble in ether, in benzene and in petroleum ether. It crystallizes in thick colorless plates and it melts at 75°.

β-Phenyl Benzalacetomesitylene, I.—From the carbinol the unsaturated ketone is readily obtained by warming it with aqueous hydrochloric acid but since it is easier to isolate and purify the ketone than the carbinol it is best to prepare it directly from the dimagnesium compound. This was accomplished by adding an equal volume of constant boiling hydrochloric acid to the ethereal layer obtained by decomposing the magnesium derivative, distilling off the ether, and warming the residue on a steam-bath for half an hour. The yellow oil solidified on cooling. The solid was recrystallized from methyl alcohol, from which it separated in thin plates melting at 104°. The yield was 82%.

β-Methyl Benzalacetomesitylene, IV.—By a slight modification of the method which has just been described it was also comparatively easy to prepare the methyl ketone which was needed for the structural work, the steps being represented as

$$C_6H_5COCH_2COC_6H_2(CH_3)_3 \longrightarrow (C_6H_5)(CH_3)C(OH)CH_2COC_6H_2(CH_3)_3 \longrightarrow \underset{\text{IV}}{(C_6H_5)(CH_3)C{=}CHCOC_6H_2(CH_3)_3}$$

The procedure was as follows. A solution of methylmagnesium iodide made from 2.3 g. of magnesium was added gradually to a solution of 25 g. of benzoyl acetomesitylene in 150 cc. of ether. The mixture, which had developed a purple color during the addition of the reagent, was boiled for seven hours, and then decomposed with iced acid in the usual manner. The ethereal layer, on evaporation, left a yellow oil which solidified when it was heated for half an hour with dilute hydrochloric acid. The solid was purified by recrystallization from petroleum ether from which it separated in large yellow prisms melting at 84°. The yield was 92.4%.

Anal. Calcd. for $C_{19}H_{20}O$: C, 86.4; H, 7.6. Found: C, 85.8; H, 7.6.

The unsaturated ketone is moderately soluble in the common organic solvents. Its structure was established by ozonization, the ozonide yielding acetophenone, identified as *m*-nitro benzalacetophenone, and mesitylene carboxylic acid, which was identified by comparison with a specimen on hand.

Action of Phenylmagnesium Bromide on Phenyl Benzalacetomesitylene, β,β,β-Triphenyl Propiomesitylene (II).—The unsaturated ketone combines with phenylmagnesium bromide to form a red intermediate complex compound which is sparingly soluble in ether, and which regenerates the ketone when it is acidified. In order to carry the reaction beyond this preliminary stage it is necessary to use dilute solutions and to add the ketone at such a slow rate that the intermediate never crystallizes from the solution. Our best results were obtained as follows. A solution of 5 g. of the ketone in 125 cc. of dry ether was added during a period of three to four hours to a solution of the reagent which had been prepared from 1.6 g. of magnesium. The mixture was boiled for five hours more, or until the red color of the solution disappeared completely. After the usual manipulation, the mixture yielded a solid product which was recrystallized from glacial acetic acid.

Anal. Calcd. for $C_{30}H_{28}O$: C, 89.1; H, 6.7. Found: C, 89.0; H, 7.0.

The saturated ketone is sparingly soluble in alcohol and ether. From glacial acetic acid it crystallizes in needles melting at 194–195°. The yield was only 60% but no other product was formed. By distilling the filtrates with steam and crystallizing the residue enough unsaturated ketone was recovered to account for all the material that had been used.

Structure of the Addition Product.—A solution of the bromomagnesium enolate of acetomesitylene was prepared by adding 16.2 g. of acetomesitylene to a solution of ethylmagnesium bromide made from 2.6 g. of magnesium and boiling the mixture for ten minutes. To this solution was added an ethereal solution of 28 g. of triphenylmethyl chloride. After a few minutes' boiling the mixture solidified. The solid, washed with water and recrystallized from glacial acetic acid, yielded 21.5 g. of the same product that had been obtained from β-phenyl benzalacetomesitylene.

Reaction with Methylmagnesium Iodide, β,β-Diphenyl Butyrylmesitylene (III).—After a number of fruitless attempts to carry out the reaction in ether, the following procedure was found to be effective. A solution of 5 g. of the ketone in 75 cc. of benzene was added in the course of half an hour to a boiling ethereal solution of methylmagnesium iodide prepared from 1.6 g. of magnesium. The resulting red solution was boiled for three hours and then decomposed in the usual manner. The benzene, on evaporation, left an oil, but when a solution of the oil in petroleum ether was cooled in a freezing mixture it deposited 3.6 g. of solid. Another gram of the same solid was obtained by distilling the filtrate with steam and treating this residue also with petroleum ether. The total yield, therefore, was 82%.

Anal. Calcd. for $C_{25}H_{26}O$: C, 87.7; H, 7.6. Found: C, 87.4; H, 7.8.

The product is soluble in all common organic solvents including petroleum ether. It crystallizes in needles and it melts at 87°. Its structure was established in the following manner. A solution of 5 g. of β-methyl benzalacetomesitylene in 75 cc. of ether was added in the course of five minutes to a solution of phenylmagnesium bromide prepared from 2 g. of magnesium. Since the color of the red intermediate addition product disappeared rapidly, the mixture was decomposed with iced acid a few minutes after all of the ketone had been added. It yielded 4.0 g. of the same product which had been obtained by the action of methylmagnesium iodide on phenyl benzalacetomesitylene. The reaction was evidently incomplete, because the yield was only 62% and nearly a fourth of the unsaturated ketone was recovered, but the yield was diminished when the mixture was boiled for several hours before it was acidified.

Reaction with Ethylmagnesium Bromide, β,β-Diphenyl Valerylmesitylene $C_2H_5C(C_6H_5)_2CH_2COC_6H_2(CH_3)_3$.—A solution of 5 g. of phenyl benzalacetomesitylene in 250 cc. of dry ether was added in the course of three hours to a solution of ethylmagnesium bromide prepared from 1.2 g. of magnesium. The color of the red intermediate compound was very persistent but it gradually faded to a light pink when the mixture was boiled for four hours. By decomposition with iced hydrochloric acid, and the usual manipulation of the ethereal layer, the mixture yielded a solid which separated from petroleum ether in needles and which melted at 106°.

Anal. Calcd. for $C_{26}H_{28}O$: C, 87.6; H, 7.9. Found: C, 87.4; H, 7.7.

β-Methyl Benzalacetomesitylene and Methylmagnesium Iodide, $(C_6H_5)(CH_3)_2CCH_2COC_6H_2(CH_3)_3$.—An ethereal solution of 5 g. of methyl benzalacetomesitylene was added in the course of a few minutes to an ethereal solution of methylmagnesium iodide which had been prepared from 1.8 g. of magnesium. The orange-colored solution soon began to deposit a colorless magnesium derivative. After ten minutes at the ordinary temperature it was decomposed with ice and acid in the usual manner. It yielded a solid which crystallized from acetic acid in colorless needles and which melted at 184–185°.

Anal. Calcd. for $C_{20}H_{24}O$: C, 85.8; H, 8.6. Found: C, 86.0; H, 8.8.

Summary

The former statement that β-phenyl benzalacetomesitylene does not add phenylmagnesium bromide is incorrect. Both β-phenyl and β-methyl benzalacetomesitylene add Grignard reagents, forming enolates of the corresponding saturated ketones.

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The Number of Stereoisomeric and Non-Stereoisomeric Alkines

BY DONALD D. COFFMAN

Since the number of structurally isomeric alkines[1] can be readily deduced from the number of structurally isomeric mono-substitution products of the paraffins,[2] an attempt has been made to calculate the number of stereoisomeric alkines.

Blair and Henze have advanced recursion formulas which[3] permit the calculation from their carbon content of the number of stereoisomeric and non-stereoisomeric primary, secondary and tertiary mono-substitution products of the paraffins. The use of these formulas depends upon the knowledge of the total number of stereoisomeric and non-stereoisomeric mono-substituted paraffins of every lower carbon content. By employing the published data of Blair and Henze, it is possible to calculate the number of stereoisomeric and non-stereoisomeric mono-substituted and

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[1] Coffman, and Blair with Henze, THIS JOURNAL, **55**, 252 (1933).

[2] Henze and Blair, *ibid.*, **53**, 3042–3046 (1931).

[3] Blair and Henze, *ibid.*, **54**, 1098–1106 (1932).