REACTIVITIES OF DYPNONE

AND RELATED COMPOUNDS

BY

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ABSTRACT

Trans-dypnone was prepared by self-condensation of acetophenone in carbon disulfide through use of aluminum chloride. Its physical constants were determined, and it was further characterized by preparation of its p-nitrophenylhydrazone, 2,4-dinitrophenylhydrazone, and anti-phenyl oxime.

Cis-dypnone was prepared by sunlight irradiation of an ethereal solution of trans-dypnone. Two polymorphic forms of cis-dypnone 2,4-dinitrophenylhydrazone were prepared, whereas the reaction product with p-nitrophenylhydrazone has not been identified.

Trans- and cis-dypnone were reacted with phenylmagnesium bromide, yielding 1,4- and 1,2-adducts; β , β -diphenylbutyrophenone, and 1,1,3-triphenyl-1,3-butadiene. The relative yields of each type of addition to each of the isomers was studied and explained on the basis of different steric hindrances set up by trans- and cis-configurations of the dypnone molecule.

Reaction of both trans- and cis-dypnone with phenyllithium (hydrochloric acid hydrolysis of the reaction mixture) produced only 1,1,3-triphenyl-1,3-butadiene in varying yields. Ammonium chloride hydrolysis of the organometallic adduct produced a carbinol, 1,1,3-triphenylbut-2-ene-1-ol, from both isomers, in yields very similar to those obtained for the dehydrated butadiene after hydrochloric acid hydrolysis. Again the effect of the trans- and cis-configurations on the yield of 1,2-addition product was discussed in detail.

Synthesis of p,p'-dimethylaminodypnone by condensation of p-N,N-dimethylaminoacetophenone was unsuccessful. Condensation of p-methoxy-

acetophenone yielded tris-1,3,5-p-methoxyphenylbenzene. Condensation of p-bromoacetophenone yielded p,p'-dibromodypnone and a compound whose analysis and molecular weight determination suggested tris-2,4,6-p-bromophenyl- 4-methylpyran. The effects of varying the reaction time, and then of varying the concentration of the aluminum chloride condensing agent, were studied.

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INTRODUCTION

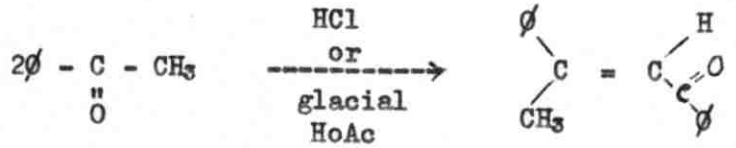
Dypnone, or β-methylbenzalacetophenone, is an α,β-unsaturated ketone, capable of 1,4- and 1,2-additions. The dypnone molecule can assume the trans- and cis-steric configurations, leading to two isomeric forms. It was deemed of interest to study the effect of the β-methyl substituent on the benzalacetophenone molecule, and, concomitantly, the steric configuration of the molecule, with respect to the mode of addition of organometallic reagents. Two organometallic compounds were used in this respect; phenylmagnesium bromide, known for its tendency towards the 1,4-type of addition, and the more reactive phenyllithium reagent, which adds predominantly in a 1,2-fashion.

The formation of dypnone has been affected by self-condensation of acetophenone. The process is thought to involve an aldol condensation. If this be the case, then the synthesis of p,p'-disubstituted dypnones would be affected by the nature of the p-substituent on the starting material. In this connection, the synthesis of a series of p,p'-disubstituted dypnones was attempted.

HISTORICAL REVIEW

A. Synthesis of Trans-dypnone:-

1) Syntheses:- Delacre synthesized dypnone in 1890 by treating acetophenone with hydrogen chloride over a period of two days (1). This synthesis was improved by Kohler in 1904 by utilizing glacial acetic acid as a catalyst; the reaction time was reduced to twenty four hours (2). This modified Delacre synthesis was the standard preparative method for thirty years (3):



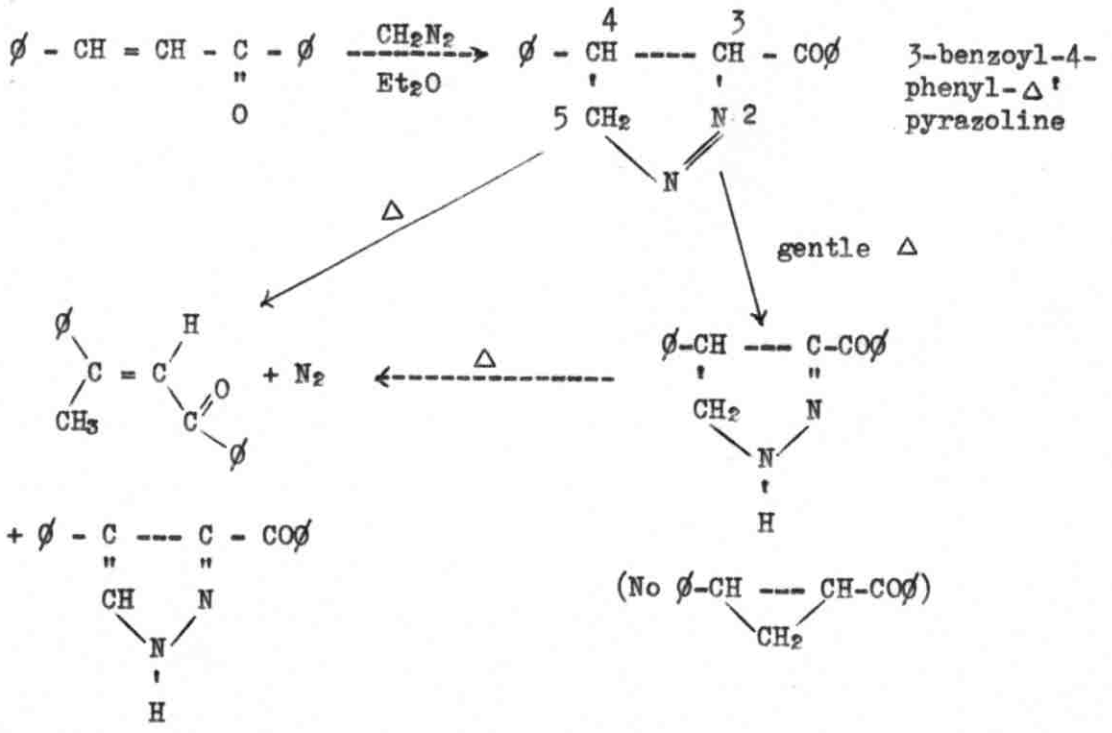
Trans-dypnone

Eijkman, in 1904, reported the first base-catalyzed synthesis of dypnone (4). He treated acetophenone with dialkyl malonate and sodium ethoxide in dry ether. He isolated several products, including dypnone, formed due to self-condensation of acetophenone under the influence of sodium ethoxide. The dialkyl malonate was not involved in the formation of the dypnone.

The synthesis developed by Calloway and Green (5) in 1937 supplanted the Kohler method as a standard means of preparation of dypnone because of the high yield and ease of the method. In this preparation acetophenone condensation is affected by treatment with aluminum chloride in carbon disulfide, giving dypnone in seventy-three percent yield.

In 1937, Smith and Pings (6) reported the only synthesis not involving acetophenone as a starting material. They treated chalcone

with diazomethane in ether and obtained the pyrazoline, which changed to dypnone after heating:

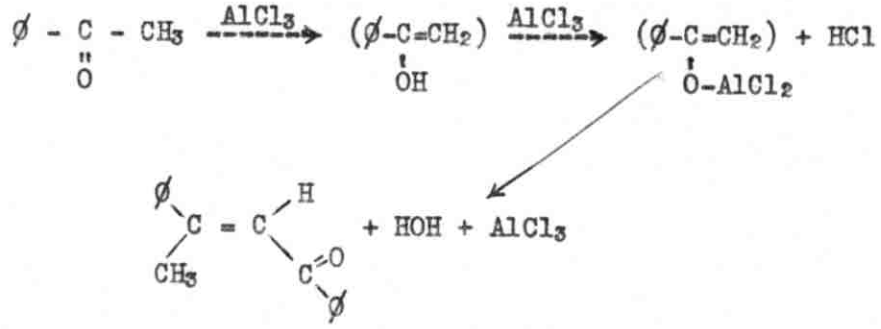


In 1938 Adkins and Cox (7) condensed acetophenone using aluminum tertiary butoxide as a condensing agent and dioxane as a solvent. This synthesis was modified by Wayne and Adkins (8) in 1940, the solvent being changed to xylene. After further modifications this synthesis was published in organic syntheses (9).

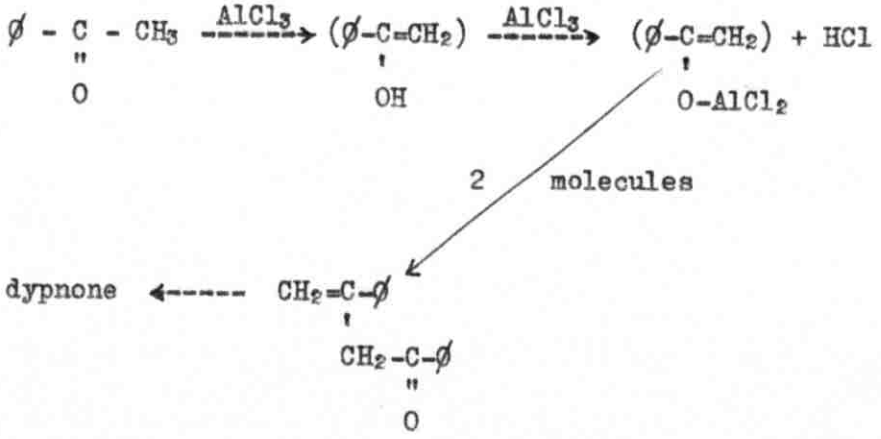
In 1956 Bader (10) synthesized dypnone by condensing acetophenone through use of hot polyphosphoric acid in an inert solvent. This synthesis is reported to be very efficient and economical.

2) Mechanistic studies:- The mechanism of the acid-catalyzed condensation of acetophenone to dypnone was first mentioned by Reddelien in 1912 (11). He postulated only that the reaction proceeded via the acetophenone enol.

Calloway and Green in 1937 (5) also suggested an enol intermediate, as shown below in their incomplete mechanism:



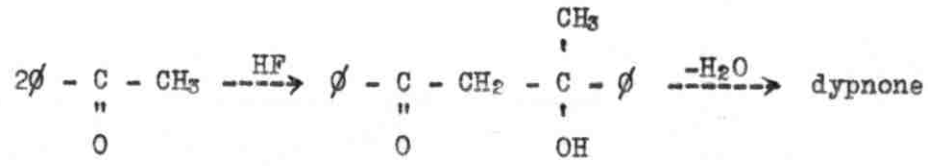
Illari (12) in 1948 suggested the following mechanism for the above reaction under the same set of conditions:



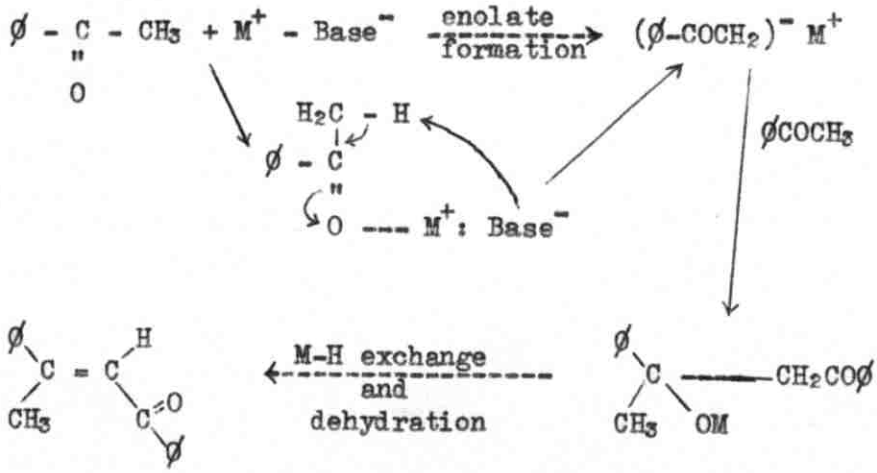
This mechanism is unsatisfactory due to its postulation of the condensation of two molecules of the last intermediate to give the dypnone tautomer (3). The mechanism may be more correctly assumed to be a condensation of a molecule of acetophenone with the last intermediate. This assumption was verified during the research leading to this thesis, see below.

Simons and Ramler (13) in 1943 proposed an aldol as an intermediate, but did not give a detailed mechanism. They used hydrogen fluoride as a

catalyst:



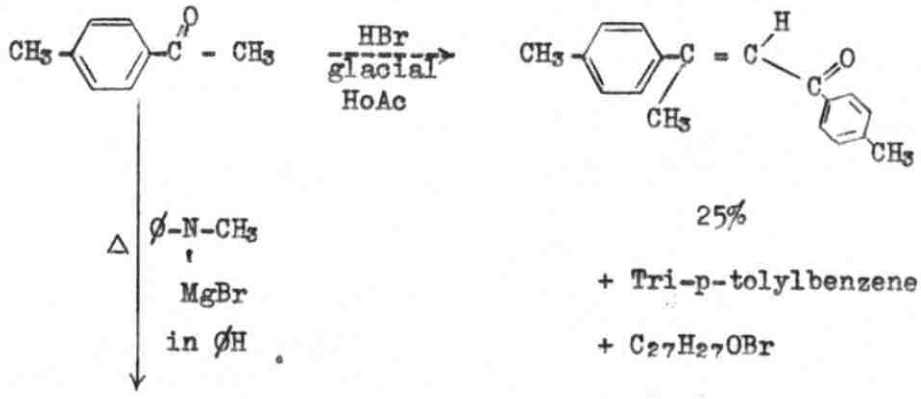
The mechanism of the base-catalyzed condensation of acetophenone to dypnone was discussed by Hauser and Puterbaugh in a paper of 1953 (14), as shown below:



Dypnone has been prepared by more than thirty different procedures, of which the most important have been discussed above. Various by-products have also been reported, of which the most frequent was triphenylbenzene.

B. Synthesis of substituted trans-dypnones:-

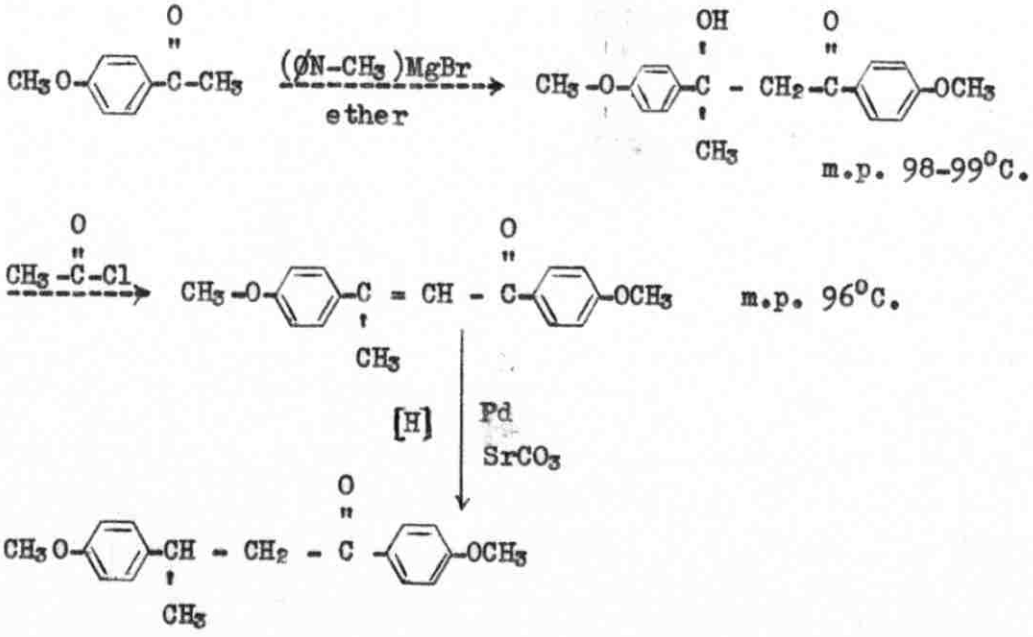
Ivanov and Ivanov (15) prepared the first substituted dypnone in 1943 in the course of their work on dypnopinacone formation. This product was the p,p'-dimethyldypnone, prepared by the action of hydrogen bromide or aminomagnesium compounds on p-tolylmethyl ketone:



53% p,p'-dimethyldypnone

m.p. 68-69°C.

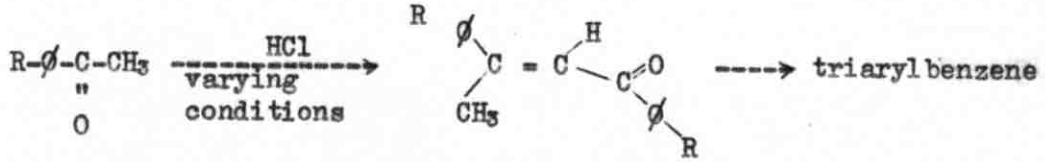
Dodds, et al. (16) synthesized p,p'-dimethoxydypnone in 1953, utilizing the aminomagnesium bromide catalyst. They treated p-methoxy-acetophenone with ethereal N-methylanilinomagnesium bromide and obtained an alcohol, which upon dehydration gave the dypnone:



Lyle and coworkers (17) in 1953 treated a large number of substituted acetophenones with hydrogen chloride under varying conditions, in an effort to obtain the corresponding triarylbenzenes. They mention that the

corresponding dypnone is an intermediate in this synthesis; whenever the dypnone is slightly soluble or insoluble in the solvent used (usually ethyl alcohol), the reaction will stop partly or completely at this stage, and thus the substituted dypnone is obtained. Since Lyle and his coworkers desired to obtain the triarylbenzenes, the yields of dypnones which they report are not the best obtainable. In many cases they obtained no dypnone whatsoever, which again should not be taken to mean that the particular dypnone in question might not be prepared in some yield from its corresponding acetophenone by varying the conditions. Thus with p-methyl-, p-methoxy-, and p-N,N-dimethylaminoacetophenone the corresponding dypnone was not obtained, only the triarylbenzenes being isolated; however, all the dypnones corresponding to the above acetophenones have been prepared by other workers, using procedures that favored the formation of the dypnone rather than triarylbenzene: p,p'-dimethyldypnone (15), p,p'-dimethoxy-dypnone (16), and p,p'-di-N,N-dimethylaminodypnone (3).

General equation for reactions run by Lyle, et al:



Nature of product dependent on conditions.

The substituted dypnones prepared by Lyle and his coworkers are tabulated below.

Table I (17)

R (in above equation)	Products
p-I	Dypnone only
p-NO_2	Dypnone only
m-NO_2	Dypnone + trace of triarylbenzene
p-bromo	Dypnone + small amount of triarylbenzene.

C. Reactions of α,β - unsaturated ketones with organometallic compounds:-

1) Generalizations governing mode of addition of different organometallic compounds to a given α-β - unsaturated ketone:

Organometallic compounds can add to the conjugated system of an α,β-unsaturated ketone in a 1,4-fashion, or to the carbonyl group giving the 1,2-addition product. It is possible to obtain the 1,2-addition product alone, the 1,4-addition product alone, or both in varying ratios, depending upon the configuration of the conjugated ketone, and the nature of the organometallic compound.

Gilman and Kirby (18), following their investigation on reactions of chalcone with a series of phenyl-metallic compounds, stated the following generalizations governing the mode of addition of different organometallic compounds to a conjugated ketone:

1) The less reactive phenyl-metallic compounds (those of beryllium, magnesium, zinc, aluminum and manganese) show predominantly 1,4-addition.

2) The highly reactive phenyl compounds of potassium and calcium show 1,2-addition.

3) Organometallic compounds of intermediate reactivity (those of sodium and lithium) show both 1,2- and 1,4-addition.

The results of the above-mentioned investigation of Gilman and Kirby are summarized in the following table:

Table II

Benzalacetophenone and C_6H_5M compounds

RM	δ,β-diphenylpropiophenone (1,4-addition, %)	Diphenylstyrylcarbinol (1,2-addition, %)
$(C_6H_5)_2Be$	90	-
$(C_6H_5)_2Zn$	91	-
$(C_6H_5)_3Al$	94	-
C_6H_5MnI	77	-
C_6H_5CaI	--	45
C_6H_5K	--	52
C_6H_5Li	13	69
C_6H_5Na	3.5	39

H. Gilman and R.H. Kirby, J. Am. Chem. Soc., 63, 2046 (1941).

With p-N,N-dimethylaminobenzalacetophenone, diphenyl-beryllium and phenylmagnesium bromide showed 1,4-addition, phenylcalcium iodide showed 1,2-addition, and phenyllithium showed both types of addition. These results are in agreement with those above.

Table III

	product of p-N,N-dimethylaminobenzalacetophenone + reagent	
Reagent	% 1,4-addition	% 1,2-addition
C_6H_5MgBr	66	-
$(C_6H_5)_2Be$	71	-
C_6H_5Li	14	76
C_6H_5CaI	--	64

H. Gilman and R.H. Kirby, J. Am. Chem. Soc., 63, 2046 (1941).

Maclean and Widows (19) reported that the reaction of p-N,N-dimethylaminobenzalacetophenone with phenylmagnesium bromide resulted in 1,2-addition. However, this reaction was again studied (18), and it was found that the addition does take place in the 1,4-fashion, according to expectations.

$$p\text{-}(CH_3)_2NC_6H_4CH{=}CH\text{-}C(=O)\text{-}C_6H_5 + \phi MgBr \longrightarrow p\text{-}(CH_3)_2NC_6H_4\text{-}CH(\phi)\text{-}CH_2\text{-}C(=O)\text{-}\phi$$

$$\phi\text{-}CH{=}CH\text{-}C(=O)\text{-}\phi + p\text{-}(CH_3)_2NC_6H_4MgI \longrightarrow p\text{-}(CH_3)_2NC_6H_4\text{-}CH(\phi)\text{-}CH_2\text{-}C(=O)\text{-}\phi$$

The result was confirmed by synthesizing the product via a different route, as shown above. Synthesis of the 1,2-addition product was accomplished using phenyllithium.

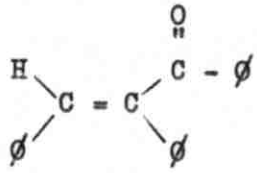
To verify the above generalizations, different organometallic compounds were reacted with benzophenone anil, which is incapable of 1,4-addition (18). Less reactive organometallic compounds, which yield a 1,4-adduct according to the above generalizations, react very slowly under the usual conditions; under forcing conditions they add by an unusual type of lateral nuclear 1,4-addition to give o-phenylbenzohydryl aniline.

On the other hand, phenyllithium and phenylcalcium iodide (which favor 1,2-addition according to the generalizations above), react quickly to give N-triphenylmethyl aniline:

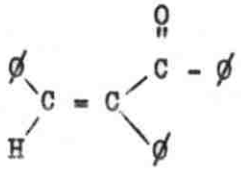
$$(C_6H_5)_2C{=}NC_6H_5 \xrightarrow[(2)\ HOH]{(1)\ \phi Li} (C_6H_5)_3CNHC_6H_5$$

(similarly for ϕK and ϕNa).

2) Effect of the steric configuration of the α,β -unsaturated ketone on the mode of addition of organometallic compounds: Lutz and Rinker (20) examined the mode of addition of organometallic compounds to a conjugated system in which geometrical isomerism occurs; trans- and cis-α-phenylchalcones were studied.



trans

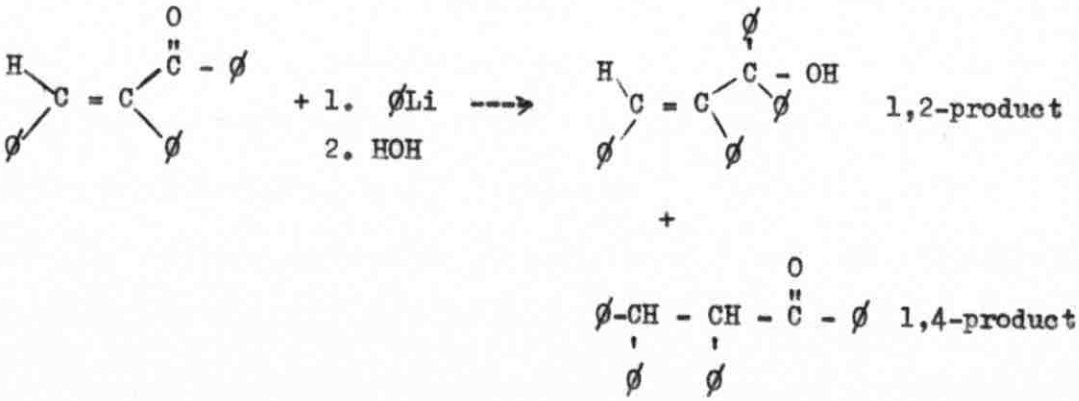


cis

Both of the two isomers added phenylmagnesium bromide at 0°C; the reaction resulted in consistent 1,4-addition to give the α,β,β-triphenylpropiophenone as the main product.

$$C_6H_5CH{=}C(C_6H_5)COC_6H_5 + 1.\ C_6H_5MgBr \rightarrow (C_6H_5)_2CH{-}CH(C_6H_5)COC_6H_5$$
$$2.\ HOH$$

Phenyllithium addition to the trans-isomer gave 33% yield of the 1,4-addition product and 48% of the 1,2-addition product.



Phenyllithium addition to the cis-isomer produced 67% of the 1,4-addition product and no 1,2-adduct.

Lutz and Rinker (20) rationalized the above results as follows: In the case of phenylmagnesium bromide addition to trans-α-phenylchalcone,

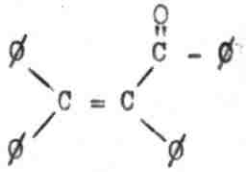
where the α,β-unsaturated ketone system terminates in a benzoyl group flanked by only one α-ethylene substituent, the product is almost completely that of 1,4-addition because of the tendency of the reagent for the 1,4-mode of addition, and because of steric hindrance to the 1,2-type of addition.

In the case of phenyl Grignard addition to the cis-isomer, where the benzoyl group is flanked by two phenyl groups, the product is again almost completely that of 1,4-addition; the reagent tends to favor the 1,4-mode of addition, and there is extreme steric hindrance to the 1,2-mode of addition. The 1,4-addition reaction proceeds more slowly than in the case of the trans-isomer.

In the case of the reaction of trans-α-phenylchalcone with phenyllithium, one must consider opposing effects; the structure of the conjugated system favors 1,4-addition, and the reagent favors the 1,2-mode of addition. The effect of the added reagent is stronger, as shown by the yields; 48% 1,2-, and 33% 1,4-, products. However, it is instructive to note that the relative proportion of 1,2-addition versus 1,4-addition is less than in the simple trans-chalcone (Table II, above), because of the steric hindrance of the α-phenyl group, opposing 1,2-addition.

In the case of cis-α-phenylchalcone, the carbonyl group is completely trapped by the α- and β-phenyl groups, so as to make 1,2-addition practically impossible, even with such a reactive reagent as phenyllithium. However, the α,β-unsaturated system, although not as effective as in the case of the trans-isomer, is not seriously hindered and is available for the 1,4-type of addition with phenyllithium, although the reaction proceeds more slowly than in the case of the trans-isomer. Consequently only 1,4-addition is observed, to the extent of 67%.

Lutz and Rinker (20) also studied α, β -diphenylchalcone,



the carbonyl group and the conjugated system of which are relatively unreactive due to steric hindrance. When treated with phenyllithium, it was found that the only product was 67% yield of the 1,2-addition product.

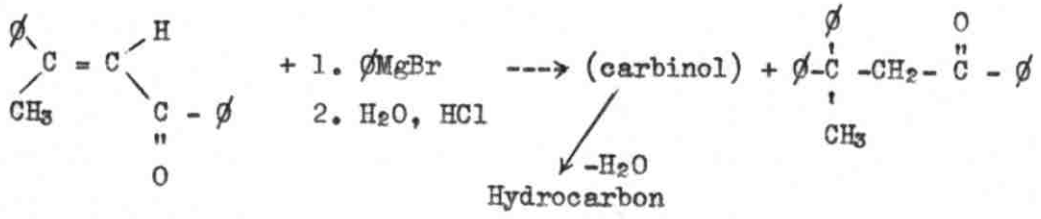
This reversal of the result with α -phenylchalcones shows the high reactivity of the reagent towards 1,2-addition, and its normal preference for 1,2-addition over 1,4-addition when both types of addition are rendered equally unfavorable due to steric hindrance. The high yield of product (67%) is surprising in a molecule showing such a high degree of hindrance.

Lutz and Weiss (21) in 1955 examined the mode of addition of phenylmagnesium bromide and phenyllithium to the trans-chalcone and its cis-isomer. Trans-chalcone added phenylmagnesium bromide 1,4-to an extent of 89%, and the "remainder of the reaction" was accounted for as 1,2-addition product. Cis-chalcone under the same conditions gave 89% of the 1,4-addition product, but no 1,2-addition product was obtained.

In the case of phenyllithium addition to trans-chalcone, 79% yield of the 1,2-addition product and 14% of the 1,4-addition product were obtained. With cis-chalcone, phenyllithium added 87% - 1,4 and only 7% 1,2 -, a result which is comparable with the mode of addition of phenylmagnesium bromide to both isomers.

These results on the modes of addition of phenylmagnesium bromide and phenyllithium to trans- and cis-chalcone are in direct agreement with the results given above for α-phenylchalcone.

3) Reaction of trans-dypnone with some organometallic reagents: Kohler (22) reported that dypnone underwent 1,4-addition and 1,2-addition upon treatment with phenyl Grignard reagent; however, only the 1,4-addition product was isolated. The carbinol obtained as a result of 1,2-addition seemed to be readily dehydrated; it was stated that hydrocarbon mixtures were obtained but were not separated. The reaction is shown below:

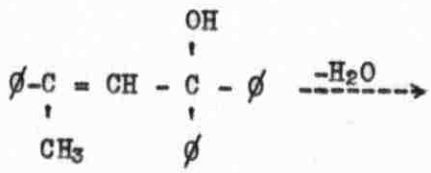


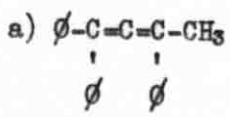
The production of 1,2-adduct as well as 1,4-adduct from the reaction of Grignard reagents with trans-dypnone can be explained by 1) increased hindrance of the conjugated system towards 1,4-addition (as compared to α-phenylchalcone or chalcone, due to the β-methyl group; 2) decreased hindrance of the carbonyl group towards 1,2-addition (again as compared to α-phenylchalcone) due to the absence of the α-phenyl group. Thus the results with trans-dypnone reinforce those given above for α-phenylchalcone.

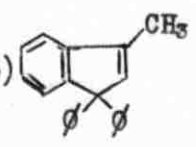
Both Kohler (22) and Freeman (23) found, with the ethyl Grignard reagent, the same relative amounts of 1,4- and 1,2-adducts (respectively 2-phenyl-2-methylvalerophenone and 2,4-diphenyl-2,4-hexadiene) as with the phenyl Grignard reagent, irrespective of the method of hydrolysis. Freeman also found that the methyl Grignard reagent produced a 1,2-adduct only, the structure of which is dependent upon the method of hydrolysis. Cold hydrochloric acid hydrolysis produced a mixture of the carbinol 2,4-diphenyl-pent-3-ene-2-ol and its dehydration product 2,4-diphenyl-1,3-pentadiene. When the carbinol was isolated and heated in an acetic acid - sulfuric acid mixture, 1-phenyl-1,3-dimethylindene was produced (23).

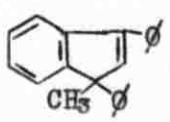
It may be noted that, as the size of the Grignard reagent decreases, its reactivity increases, as demonstrated by the above results. Methylmagnesium bromide produces only a 1,2-adduct with trans-dypnone, a characteristic of very reactive organometallic reagents. Thus it can be seen that the effect of small alkyl groups on the Grignard reagent is in opposition to the predilection of the magnesium atom for 1,4-addition. Kohler (22), who lacked the evidence of the methylmagnesium bromide experiment performed by Freeman (23), drew the erroneous conclusion that ease of 1,2-attack (and 1,4-attack) was not greatly affected by changing the nature of the alkyl group of the Grignard reagent. Kohler's conclusion was based on a comparison of ethyl- and phenylmagnesium bromides; this comparison is dubious because of the distinctive steric and electronic factors associated with benzene rings.

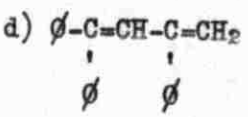
It was mentioned that the addition of phenyl Grignard reagent to dypnone produced a ketone of established structure and a hydrocarbon (due to 1,2-addition followed by dehydration) which was <u>not</u> isolated. Freeman (23) in 1957 studied the reaction again and was able to isolate a hydrocarbon of the composition $C_{22}H_{18}$, besides the usual product due to 1,4-addition. Assuming no rearrangement (except double bond migration) in the dehydration of the intermediate alcohol, Freeman suggested four structures for the hydrocarbon:



a) 

b) 

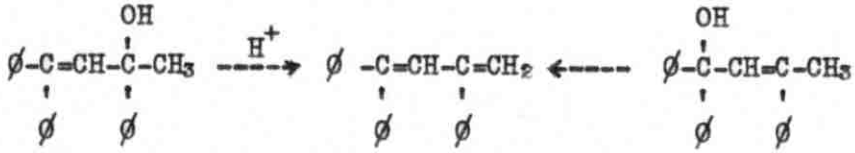
c) 

d) 

(Freeman apparently did not recognize the possibility of an allylic rearrangement in the initial carbinol; however, such a rearranged carbinol would lead to the same possibilities in dehydration products. This subject will be discussed in more detail later in this thesis).

(a) = 1,1,3-Triphenyl-3-methylallene; (b) = 1,1-diphenyl-3-methylindene; (c) = 1,3-diphenyl-1-methylindene; (d) = 1,1,3-triphenyl-1,3-butadiene.

The allene (a) and 1,3-diphenyl-1-methylindene (c) are known (24),(25) and were ruled out on the basis of their melting points. The indene (b) was prepared by dehydration of the carbinol obtained from the reaction of methylmagnesium bromide with 3,3-diphenylindanone-1, and it was quite different from the compound under investigation here. Finally, the same hydrocarbon under investigation here was obtained by acid dehydration of 1,1,3-triphenylbuten-1-ol-3:



(d)

Freeman concluded that the structure of the hydrocarbon should be that of 1,1,3-triphenyl-1,3-butadiene (d). This conclusion was supported by a chromic acid oxidation yielding benzophenone (only isolable product). Reduction of the above hydrocarbon gave a saturated hydrocarbon $C_{22}H_{22}$. Also, infrared spectroscopy showed the characteristic vibrational absorption of the $R_2C = CH_2$ group.

Freeman (23) also tried the reaction of phenyllithium with transdypnone. It resulted predominantly in 1,2-addition, with only traces of the 1,4-adduct. The final product was dependent on the method of hydro-

lysis. Hydrochloric acid hydrolysis gave the dehydrated product 1,1,3-triphenyl-1,3-butadiene; with ammonium chloride hydrolysis an oil was obtained, the infrared spectrum of which showed an hydroxyl band. The pure carbinol was not isolated. The oil was dehydrated with an acetic acid - sulfuric acid mixture. Again an oil was obtained, the infrared spectrum of which suggested a mixture of 1,1-diphenyl-3-methylindene and 1,3-diphenyl-1-methylindene. The nature of the undehydrated product will be discussed below.

This 1,2-addition of phenyllithium to trans-dypnone is to be expected in view of the forgoing discussion; both the reagent and the α, β -unsaturated ketone reinforce 1,2-addition (the β -methyl group of the ketone sets up steric opposition to 1,4-addition).

THEORETICAL DISCUSSION

A. Trans-dypnone:

Trans-dypnone was prepared according to the directions of Calloway and Green (5). Acetophenone and anhydrous aluminum chloride were reacted in a molar ratio of 2:1 in carbon disulfide, as shown below.

$$2\,\phi - \overset{O}{\overset{\|}{C}} - CH_3 \xrightarrow[CS_2]{AlCl_3} \phi - \underset{CH_3}{\underset{|}{C}} = CH - \overset{O}{\overset{\|}{C}} - \phi + H_2O$$

(The above reaction is sensitive to humidity, and it was found that drying the reagents greatly increased the yield). This method is reported to give a maximum yield of 73% (5). The organic syntheses (9) preparation, which utilizes aluminum tertiary butoxide as a dehydrating agent, gives a yield which is 4% - 9% higher, but it requires a more laborious procedure. The synthesis of Bader (10) gives higher yields of dypnone, but the comparative simplicity and satisfactory yields of the Calloway and Green synthesis caused it to be used.

The ultraviolet spectrum of the dypnone obtained showed absorption maxima at 227.5 mu and 295 mu, which compared favorably with reported values of 225 mu and 295 mu (3), but the extinction coefficients at the maxima were lower than the reported values (3). At λ = 227.5 mμ ϵ = 6500, and at λ = 295 mμ, ϵ = 15400, compared to values of 10000 and 18000 as reported earlier (3). Upon measuring the extinction coefficients of a redistilled sample boiling in a narrow range (1 mm.), no change was noted. Other physical constants (infrared spectrum, boiling point, density, and refractive index) checked closely with the literature

values (see experimental section of this thesis).

The trans-dypnone was characterized by preparation of its p-nitrophenylhydrazone (a new derivative), 2,4-dinitrophenylhydrazone, and anti-phenyl oxime. Although the 2,4-dinitrophenylhydrazone has been reported to melt at 170°C (26), and 174°C (3), the compound prepared melted at 164 - 165°C. Its ultraviolet spectrum was similar to that reported before (3), although the extinction coefficients were again lower than the values reported. However, the above compound was microanalyzed for carbon and hydrogen, and the values found check very closely with the theoretical values. These facts suggest that there may exist polymorphs of trans-dypnone 2,4-dinitrophenylhydrazone (see below on cis-dypnone 2,4-dinitrophenylhydrazone).

Attempts to prepare the trans-dypnone semicarbazone were unsuccessful, although the derivative is reported in the literature (3), (27).

B. Cis-dypnone:

Cis-dypnone was prepared by sunlight irradiation of trans-dypnone. The extent of conversion was followed spectrophotometrically. The photoequilibrium mixture has two maxima in the ultraviolet absorption region, at 256.5 mμ and 284 mμ, with corresponding extinction coefficients of 12400 and 9400, corresponding to a ratio of 1.32 (3). (Pure cis-dypnone has λ_{max} = 257.5 mμ and 287.5 mμ, with ϵ = 13500 and 11500; ratio = 1.17 (3)). The conversion of trans-dypnone to cis-dypnone was assumed complete in routine preparation in this research when the photoequilibrium mixture showed maximal absorption at λ = 255 mμ and 285 mμ (these wavelengths check with the above reported values for the photoequilibrium mixture within experimental error), and when the photoequilibrium mixture attained a peak height ratio of 1.27. This peak height ratio corresponds to 96%

conversion. Continued irradiation did not show any change.

The solvent used in the literature (3) and used initially during this work was 95% ethyl alcohol. However, after distilling the alcohol on a steam bath in order to get the pure oil, spectrophotometric examination of the residue showed partial reconversion to trans-dypnone. Ethyl ether was then used, since it could be removed easily by distilling under reduced pressure without resorting to heat. It proved to be a satisfactory solvent. In another experiment pure trans-dypnone was irradiated directly, and it was found to isomerize quickly and efficiently if spread in a thin layer, but very sluggishly if in bulk quantities; consequently the technique is not feasible for preparation of cis-dypnone on a practical scale. Stobbe and Bremer (28) reported that trans-dypnone did not isomerize when the pure oil was irradiated, which statement is now seen to be in error; they further stated that trans-dypnone did not isomerize in alcohol solution, which latter statement is also in error.

The cis-dypnone used in the subsequent reactions was the oil left after removing the ether solvent from the irradiated solution. It was assumed that the polymerization products (maximum 4%) are negligible, and the oil was not further purified by vacuum distillation because of the likelihood of reconversion during the process. This vacuum distillation was attempted on a small scale, and it did cause extensive reconversion; this tendency towards reconversion during vacuum distillation has been noted before (3), although the distillation has in isolated cases been

successfully performed without reconversion (3). The product of this successful vacuum distillation is the source of the ultraviolet spectral data of pure cis-dypnone, mentioned above (3).

Cis-dypnone 2,4-dinitrophenylhydrazone was prepared by the general method of Shriner and Fuson (29). Two pink crystalline compounds were isolated, with different melting points. One of these products melts at 141 - 143°C and is easily soluble in many organic solvents; the other compound melts at 212.5 - 213.5°C and is sparingly soluble in most usual solvents. The infrared and ultraviolet absorption spectra of these compounds are almost identical, and microanalysis of both compounds for carbon and hydrogen showed the same results (within experimental error); the analysis checks for dypnone-2,4-dinitrophenylhydrazone. Thus it appears that the above compounds are polymorphic forms. Cis-dypnone-2,4-dinitrophenylhydrazone has been reported with still another melting point (184 - 185°C.) (3), lending weight to the possibility of polymorphism (see above, trans-dypnone 2,4-dinitrophenylhydrazone).

Synthesis of cis-dypnone p-nitrophenylhydrazone was attempted, and a compound melting at 160 - 161°C was obtained. Analysis of this compound does not correspond with that of the p-nitrophenylhydrazone. The compound has not been identified.

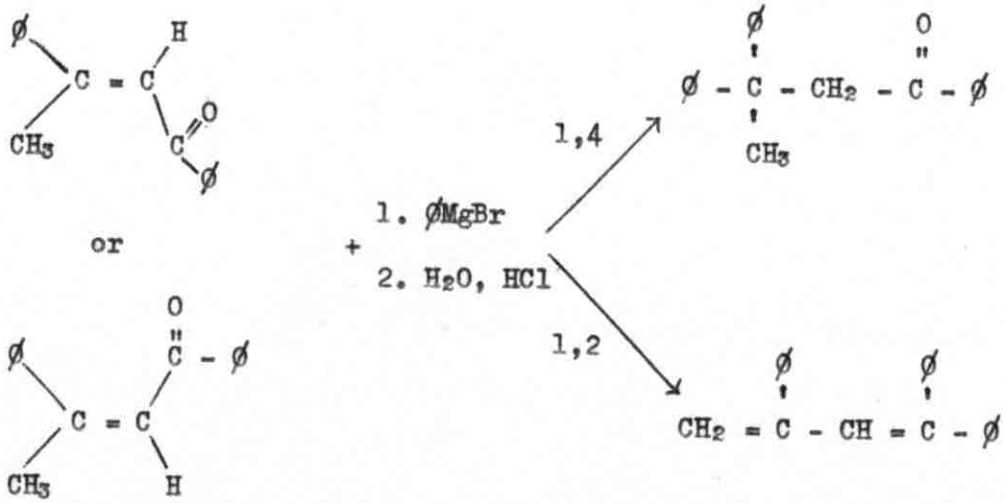
Attempts to prepare cis-dypnoneoxime and cis-dypnonesemicarbazone were unsuccessful. Both derivatives are reported in the literature (3).

C. Organometallic reactions of Trans- and Cis-dypnone:

During the research which led to this thesis the work of Freeman (23) on addition of organometallic compounds to trans-dypnone was repeated, and the same series of reactions was carried out on cis-dypnone, in order to study the effect of steric configuration on the reactivity of the molecule.

The two organometallic reagents used were the phenyl Grignard reagent and phenyllithium. With the latter reagent, different methods of hydrolysis were employed, leading to different products. The relative yields of the two possible types of addition products (1,4- or 1,2- adducts) were calculated for each isomer in each reaction and then studied to conclude whether or not they corresponded to what would be predicted from the criteria of steric hindrance, organometallic activity, etc. (18 - 23; see historical review, above).

1) Addition of Phenylmagnesium bromide to trans-dypnone yielded the 1,4-addition product, β ,β -diphenylbutyrophenone, in 36% yield, and the 1,2-addition product, 1,1,3-triphenyl-1,3-butadiene, in 25% yield. Freeman (23) obtained corresponding yields of 40% and 28%.



It should be noted that the initial 1,2-addition product is a carbinol, but it exists only as an intermediate in the presence of the acidic hydrolyzing medium. The isolated product is the butadiene.

The results of this reaction are in agreement with predictions based on earlier work (18, 20, 22, 23); the β -methyl group of dypnone creates steric hindrance to 1,4-addition, whereas the Grignard reagent

favors 1,4-addition over 1,2-addition (18); these opposing factors result in a mixture of 1,4- and 1,2-addition in which 1,4-addition predominates, indicating the high degree of activity of the Grignard reagent towards 1,4-addition.

On repeating the above reaction with cis-dypnone, β ,β -diphenylbutyrophenone was obtained in 9.3% yield, while the 1,2-addition product, 1,1,3-triphenyl-1,3-butadiene, was obtained in 5.9% yield.

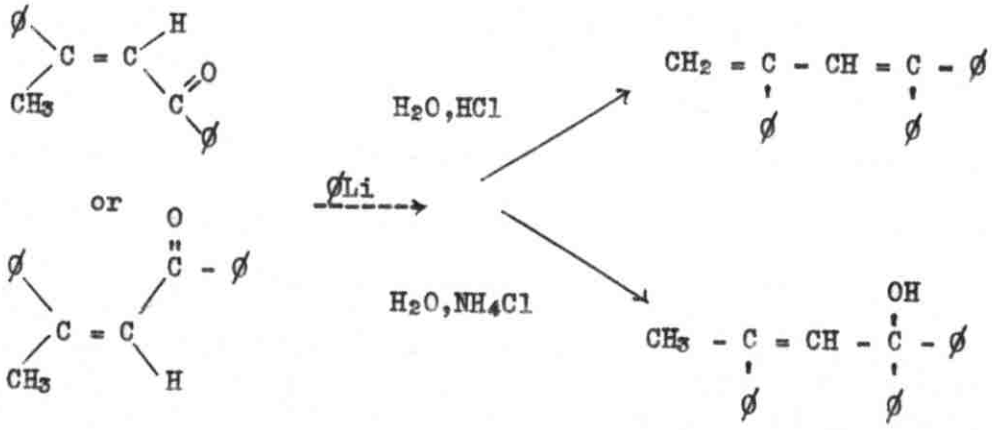
The results obtained with the cis-isomer are in conformity with what is expected. Since the bulky phenyl group cis- to the phenacyl group will provide steric hindrance to 1,2-addition, and thus make the cis-dypnone much less reactive towards 1,2- attack than its trans-isomer, one should expect an increase in the relative yield of the 1,4-addition product; this increase was found, although it is very slight, as shown by table IV. The low yields in the case of cis-dypnone are directly attributable to the extreme hindrance and nonplanarity of the molecule, which is hindered with respect to both 1,2- and 1,4-attack.

Table IV

	Trans-dypnone	Cis-dypnone
% yield of 1,4-addition product	36	9.3
Relative yield, %	59	61
% yield of 1,2-addition product	25	5.9
Relative yield, %	41	39

Phenylmagnesium bromide is known to favor 1,4-addition (18). Both trans- and cis-α-phenylchalcones (20), and trans- and cis-chalcones (21), added the above reagent and gave predominantly 1,4-addition. (see the foregoing historical review).

2) Addition of phenyllithium to trans- and cis-dypnone gave only 1,2-addition product. After addition of phenyllithium, the structure of the final product was dependent on the method of hydrolysis. An ice-hydrochloric acid mixture yielded the hydrocarbon 1,1,3-triphenyl-1,3-butadiene, while an ice-ammonium chloride mixture yielded the carbinol 1,1,3-triphenylbut-2-ene-1-ol, which is a new compound.



The yields as reported in table V are almost identical for the products of both types of hydrolysis.

Table V

Reactant	% yield of 1,2-addition product	
	HCl-H_2O hydrolysis	NH_4Cl-H_2O hydrolysis
Trans-dypnone	36%	38%
Cis-dypnone	28.6%	29%

Freeman (23) carried out the addition of phenyllithium to trans-dypnone and, after filtration of the crystals of 1,1,3-triphenyl-1,3-butadiene, he obtained a weight corresponding to 37% yield; he then subjected the filtrate to chromatography and increased the yield by 9% to a total of 46%. It will be noted that his yield before chromatographic

treatment is almost identical to the yield obtained in this work, in which the filtrate was not subjected to chromatography. He reported only traces of 1,4-addition product, obtained after chromatographic treatment.

Phenyllithium is an active organometallic compound which is known to add in a 1,2-fashion preferentially (18), but which will add 1,4- when there is strong hindrance to 1,2-addition. Lutz and Rinker (20) studied the reaction of phenyllithium with trans- and cis-α-phenylchalcones, in which this strong hindrance to 1,2-addition exists; they obtained 33% yield of the 1,4-addition product and 48% of the 1,2-addition product with the trans-isomer, while the highly hindered cis-isomer yielded 67% of the 1,4-addition product only. (See historical review, above).

In the case of β-methylchalcone (dypnone), even with the cis-isomer, the carbonyl group is still not as hindered as in α-phenylchalcone, and consequently phenyllithium will add predominantly in a 1,2-fashion. The steric configuration in the case of the cis-isomer will cut down the yield but will not affect the mode of attack of the reagent. It should be noted that the presence of the β-methyl group, setting up steric hindrance to 1,4-addition, reinforces the tendency of the phenyllithium to add to the carbonyl group.

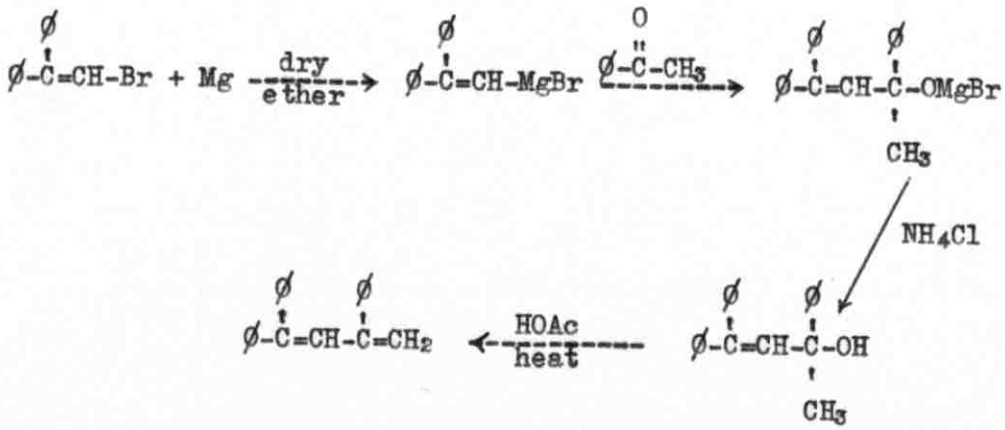
Since the reaction of cis-dypnone with phenyllithium gives the same products as the reaction of trans-dypnone (in both methods of hydrolysis) it cannot easily be proven whether the cis-dypnone losesits configuration prior to, or after, the addition step. However, since phenylmagnesium bromide does not stereoisomerize cis-dypnone before adding (trans- and cis-dypnone give radically different yields), it may reasonably be postulated that phenyllithium also does not stereoisomerize the cis-dypnone.

3) Characterization of the products of the additions of phenylmagnesium bromide and phenyllithium to trans- and cis-dypnone:

The products obtained directly after the reactions were oils, freely soluble in organic solvents (although the hydrocarbon 1,1,3-triphenyl-1,3-butadiene is insoluble in alcohol when pure). It was necessary to leave the thin oil in the cold until it thickened, after which it could be worked up as described in the experimental part of this thesis.

The 1,4-addition product, α,β-diphenylbutyrophenone, has been reported by Freeman (23) to melt at 99 - 102°C. The samples obtained during this investigation melted at 97 - 99°C. The λ_{max} = 242.5 mμ, corresponding to the absorption of the unconjugated benzoyl group. The infrared spectrum showed the characteristic carbonyl band, and mono-substituted phenyl absorption.

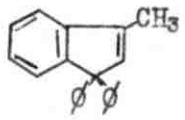
The hydrocarbon obtained upon acid hydrolysis of the 1,2-addition product has been shown to be 1,1,3-triphenyl-1,3-butadiene (23, and historical section of this thesis). It has been reported to melt at 164 - 167°C. (23). Ziegler and Sauermilch (24) prepared the above compound as follows:



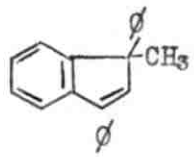
They reported a melting point of 163°C. The compound obtained during this research melted at 160-162°C. The λ_{max} = 252.5 mμ (literature λ_{max} = 252 mμ (23)), corresponding to the styryl linkages of the conjugated

butadiene system.

The product from ammonium chloride hydrolysis of the 1,2-addition reaction mixture has been suggested to be a carbinol; it was mentioned as such by Kohler (22). Freeman (23) reported it but also did not isolate it. He treated the ammonium chloride hydrolysate with acetic acid under reflux for one hour to effect dehydration. He obtained an oil which he chromatographed on alumina. The oil boiled at 160-165°C (0.1 mm); λ_{max} = 231, 265 mμ. He concluded that the mixture contained both 1,1- and 1,3-diphenyl-3-methylindene(I,II), on the basis of the spectral data and elementary analysis.

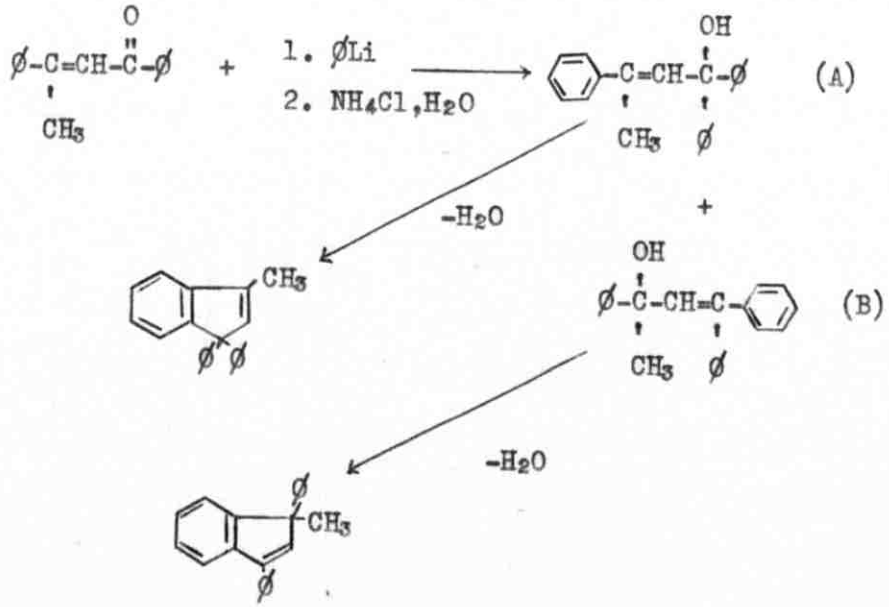


I



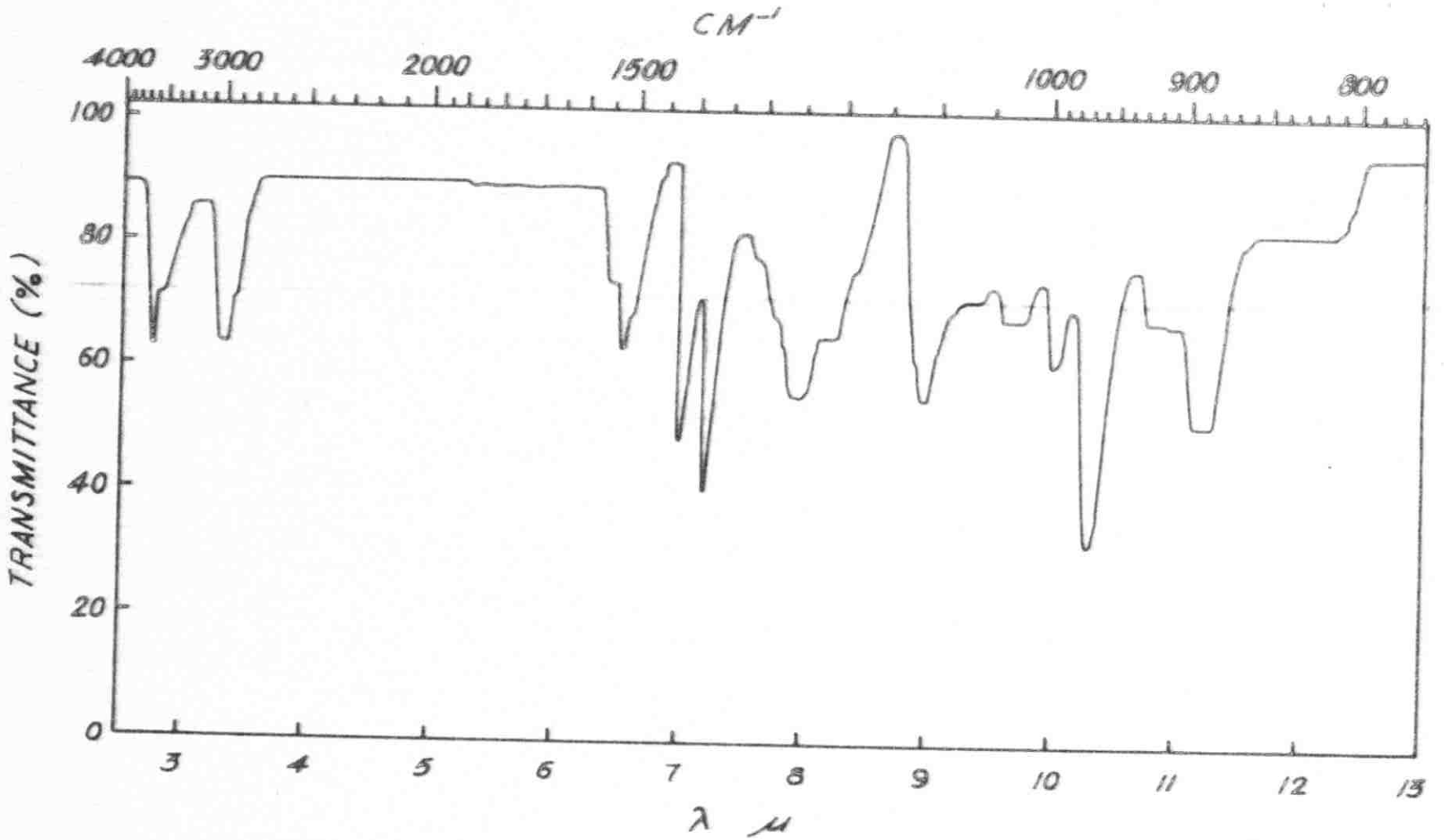
II

This postulation suggests that, besides the expected carbinol from 1,2-addition to dypnone, the allylic rearrangement product may also be present:



During the investigation leading to this thesis the carbinol was obtained in pure crystalline form for the first time. It is a colorless crystalline compound melting at 85 - 86°C. Its microanalysis fits the required percentages, and its infrared spectrum shows absorption bands characteristic of the groups present. The λ_{max} = 247.5 mμ (ϵ = 13720), corresponding to the absorption of the simple styryl group. All the above evidence can fit carbinol (A) or the product of the allylic rearrangement, carbinol (B), in the above reaction sequence; however, carbinol (B) has been prepared by Ziegler and Sauermilch (24) (see above) and was found to melt at 61°C. Thus it is evident that carbinol (A), 1,1,3-triphenyl-but-2-ene-1-ol, is the product of the addition of phenyllithium to dypnone when mild hydrolysis is employed. It should be noted that the yields of the above reactions, in the case of both hydrochloric acid and ammonium chloride hydrolysis, are almost equal (see table V) which is an evidence that no other product is obtained in the latter case (ammonium chloride hydrolysis) except the product reported.

If the possibility of allylic rearrangement of the carbinol formed in the course of this research is insisted upon, it becomes equally necessary to postulate an allylic rearrangement of the Ziegler and Sauermilch carbinol. It seems highly improbable that both of these reactions yield carbinols which are the results of allylic rearrangements. It should be noted, however, that assignment of the unrearranged structure (A) to the product of this research does not preclude the possibility of its allylic rearrangement in the course of subsequent reactions; thus this rearrangement may indeed take place in the process of dehydration with boiling acetic acid, leading to the two indenes suggested by Freeman (see above, (23)).



1,1,3 - Triphenylbut-2-ene-1-ol

Fig. 1

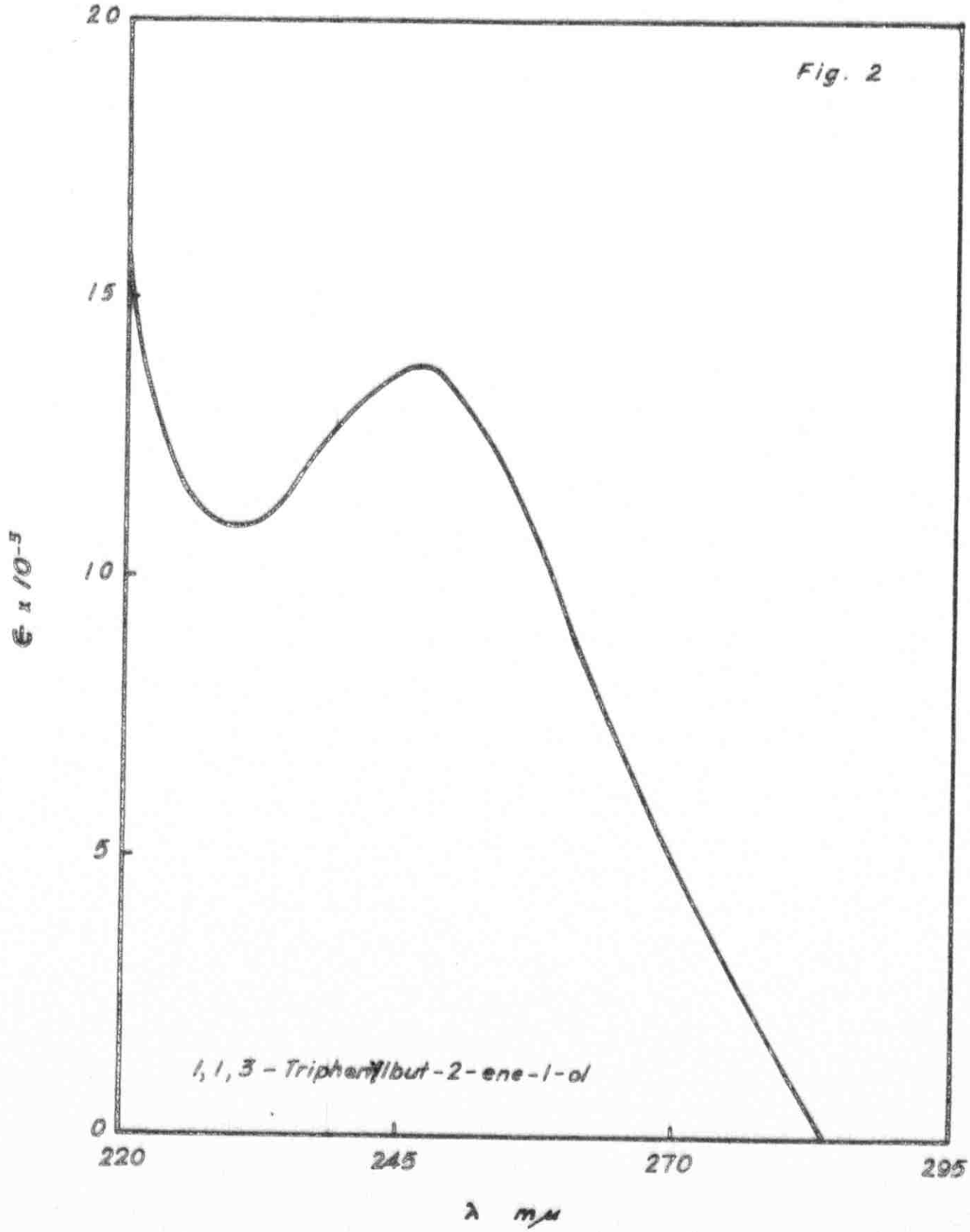
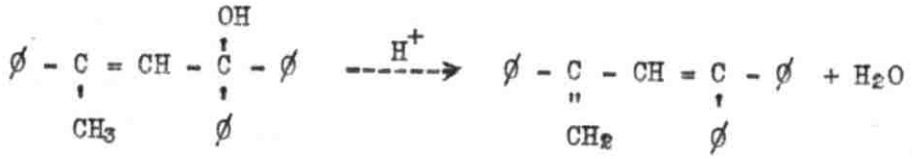

20
15
10
5
0
220
245
270
295
ε x 10⁻³
λ mμ
1, 1, 3 - Triphenylbut-2-ene-1-ol

Fig. 2

The carbinol obtained was further characterized by dehydration with hydrochloric acid in the cold to yield 1,1,3-triphenyl-1,3-butadiene.

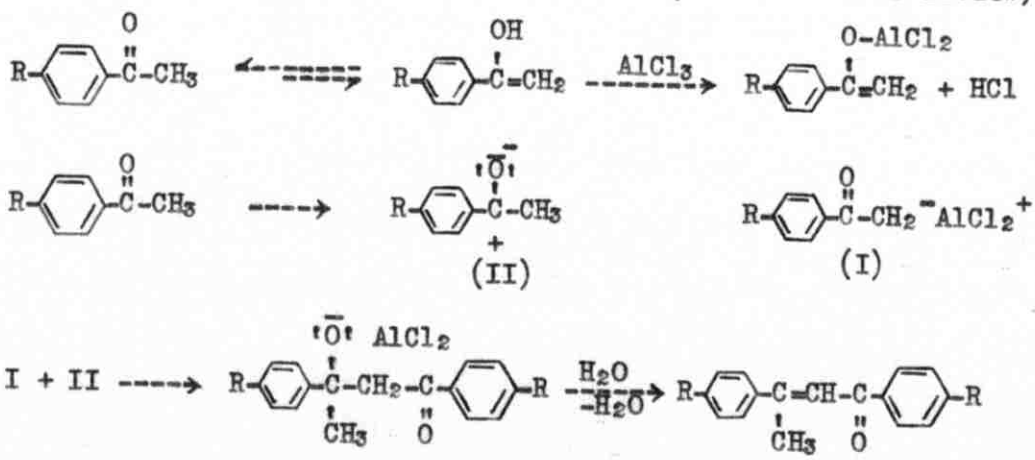


The structure of carbinol (A) gives rise to two geometric isomers, but it was found that the same compound was obtained from both trans- and cis-dypnones. It seems likely that the cis-isomer of carbinol (A) would be unstable under experimental conditions, due to steric hindrance, and consequently would be converted to trans- as soon as it formed.

D. Attempted syntheses of p,p'-disubstituted dypnones:

The synthesis of a series of p,p'-disubstituted dypnones was attempted for the purpose of studying the inductive and / or resonance effects of the p-substituents of the starting acetophenones on the yields of dypnones.

The method of synthesis is analogous to the Calloway and Green synthesis of dypnone (5). The p-substituted acetophenone was treated with aluminum chloride in carbon disulfide. The mechanism of this aldol-type condensation can be represented as follows (see historical review).



The above mechanism suggests the following:

a) A p-substituent (R) which is electron-repelling is unfavorable, because it will partly neutralize the positive charge on (II) and thus make attack of (I) less probable. An electron-attracting group should produce the opposite effect. In this connection it can be pointed out that p,p'-diiodo- (17), p,p'-dinitro- (17), m,m'-dinitro- (17), and p,p'-dibromodypnones (17), (3), in all of which the p-substituents are indeed electron-attracting, have all been prepared in satisfactory yields.

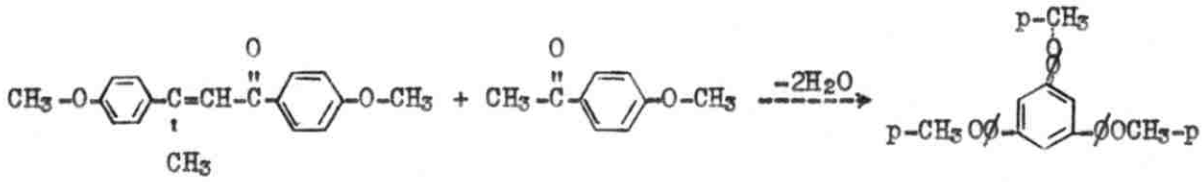
b) Optimum quantity of aluminum chloride for maximum yields is 1 mole to 2 moles of the acetophenone.

In the course of the research leading to this thesis, the condensations of p-N,N-dimethylaminoacetophenone, p-methoxyacetophenone, and p-bromoacetophenone were studied.

The condensation of p-N,N-dimethylaminoacetophenone to p,p'-di-N,N-dimethylaminodypnone was attempted only once, unsuccessfully. This dypnone has, however, been prepared (3) in 16% yield. The failure of the preparative reaction for the compound in this work, and the low yield (16%) in which it has been prepared (3), are results to be expected in view of the electron-donating nature of the p-dimethylamino group on the starting acetophenone.

The attempt to synthesize p,p'-dimethoxydypnone involved a prolonged period of standing of the reaction mixture before hydrolysis (see synthesis of dypnone - experimental part of this thesis); the prolonged standing period was used in an effort to overcome the adverse effect of the electron-donating p-methoxy group on the acetophenone. The reaction yielded a colorless crystalline compound, the infrared spectrum of which showed no

characteristic carbonyl absorption. Melting point and analysis of this compound checked for tris-1,3,5-p-methoxyphenylbenzene. The yield was only 9%. This compound is probably the result of condensation of one molecule of the dypnone (not isolated) and one molecule of the substituted acetophenone, in the usual fashion.



Not isolated

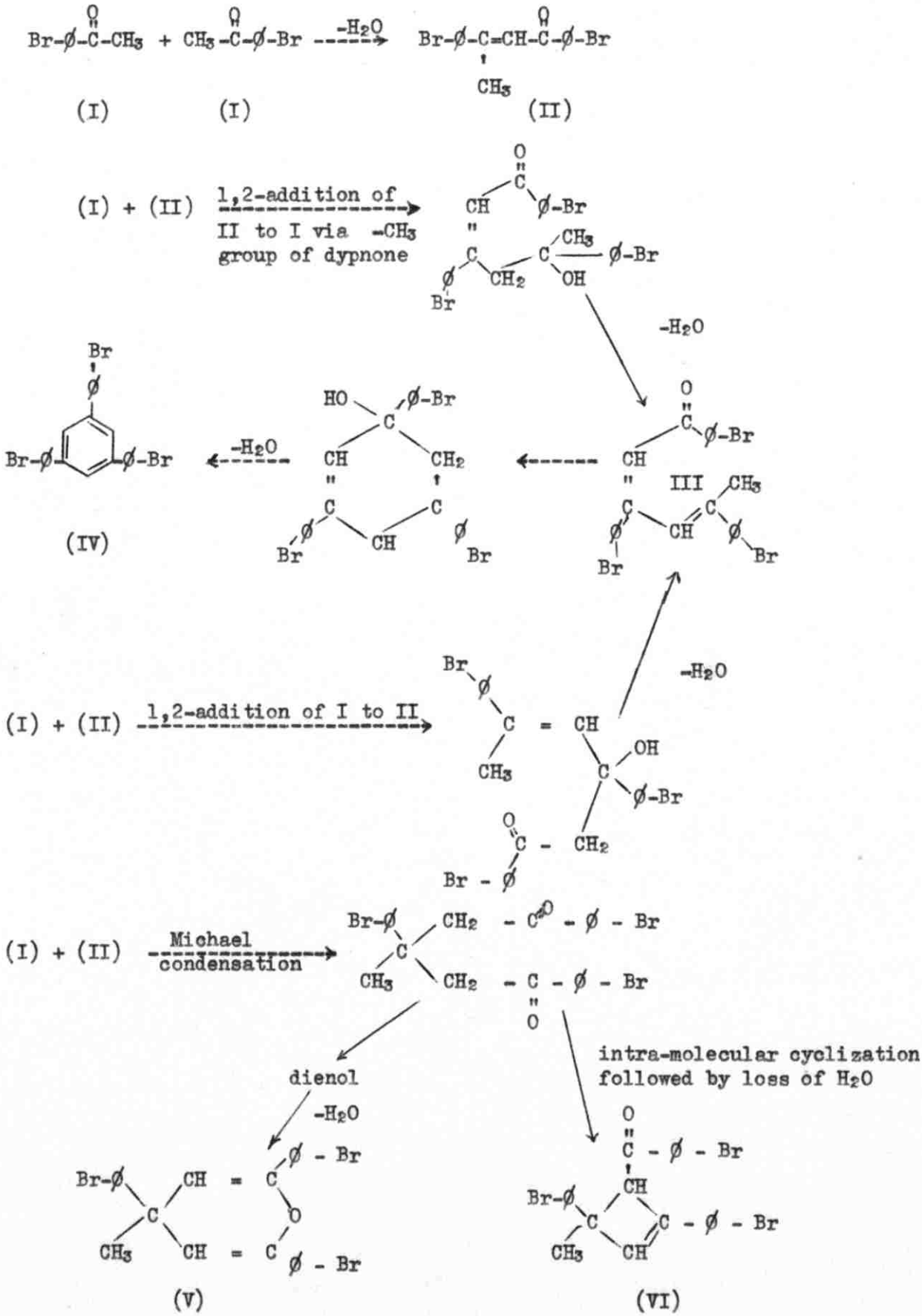
The most favorable conditions for the formation of the above compound would be 0.66 mole of aluminum chloride to 1 mole of the acetophenone.

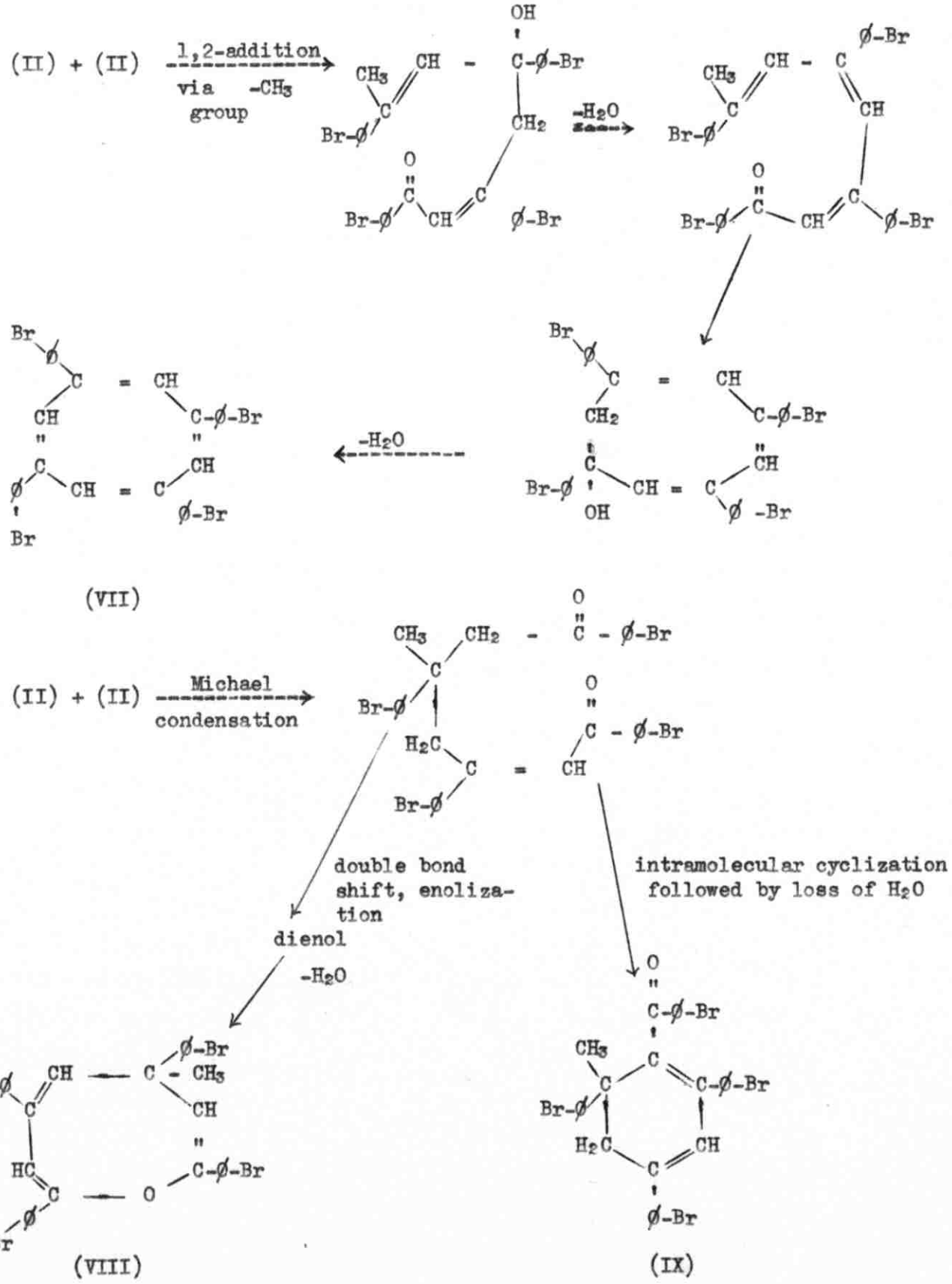
The low yield of the triphenylbenzene is as expected in view of the electron-repelling nature of the p-methoxy group.

Lyle and Coworkers (17) prepared the above trisubstituted benzene from p-methoxyacetophenone in 54% yield, but they used extreme conditions which favor the formation of the substituted benzene. They did not obtain any of the dypnone.

Again the dypnone has been prepared, by Dodds and Coworkers (16), but by a procedure different from the procedure employed in the investigation under discussion.

The condensation reaction on p-bromoacetophenone gave, besides a small quantity of the expected dypnone, a yellow crystalline product which melted at 133 - 134°C. This compound was assumed to be a condensation product of the substituted acetophenone. On the basis of the above assumption, the possibilities will be the following:


-H2O
(I)
(I)
(II)
(I) + (II)
1,2-addition of II to I via -CH3 group of dypnone
-H2O
(IV)
-H2O
III
(I) + (II)
1,2-addition of I to II
-H2O
(I) + (II)
Michael condensation
dienol
-H2O
intra-molecular cyclization followed by loss of H2O
(V)
(VI)


(II) + (II)
1,2-addition via -CH3 group
-H2O
(VII)
(II) + (II)
Michael condensation
double bond shift, enolization
dienol
-H2O
intramolecular cyclization followed by loss of H2O
(VIII)
(IX)

Compounds (II) and (IV) can be ruled out on the basis of their melting points. Compound (II) (the expected p,p'-dibromodypnone) melts at 104 - 105°C (3), while compound (IV) melts at 262°C (17). All of the compounds containing a hydroxyl group or a carbonyl group (II, III, VI, IX, and certain intermediates) are ruled out on the basis of the absence of the characteristic hydroxyl and carbonyl absorptions in the infrared region (figure 3). Further evidence against a product containing a carbonyl group is provided by the failure of the attempt to prepare a 2,4-dinitrophenylhydrazone derivative.

The only remaining possibilities are thus compounds (V), (VII), and (VIII).

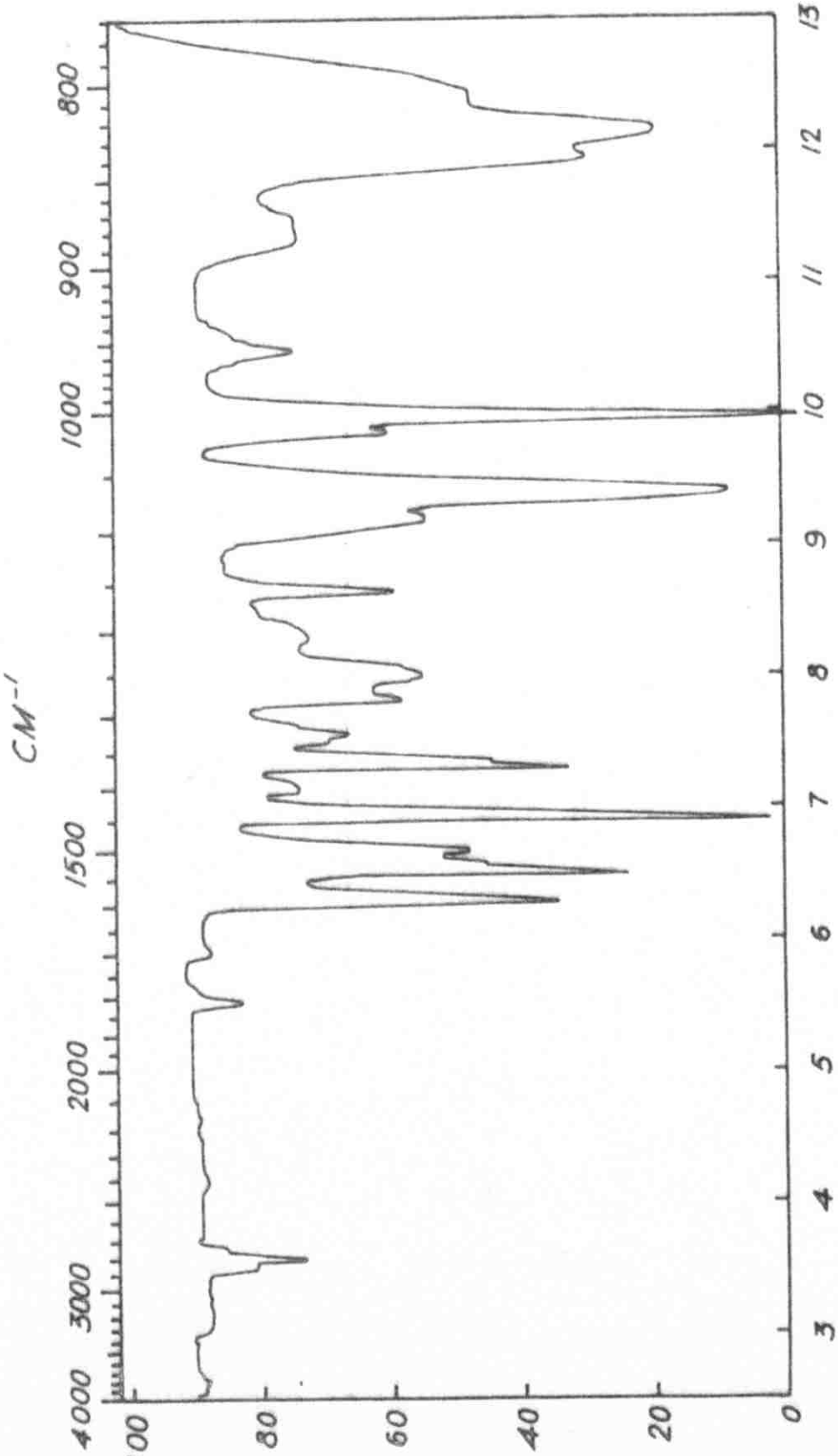
The compound was analyzed three times; it was recrystallized prior to each analysis, with no shift in original melting point. The values found are listed in table VI together with the values required for compounds (V), (VII), and (VIII).

Table VI

	% C	% H	%Br
found (1st analysis)	50.40, 50.50(1)	2.80, 3.03(1)	44.31, 44.81(1)
found (2nd analysis)	51.55	3.24	22.21(2)
found (3rd analysis)	51.55	3.33	44.93
Required for (V)	51.08	3.08	42.65
Required for (VII)	53.07	2.78	44.14
Required for (VIII)	51.78	2.99	43.07

(1) Double determination.
(2) Probably an error.

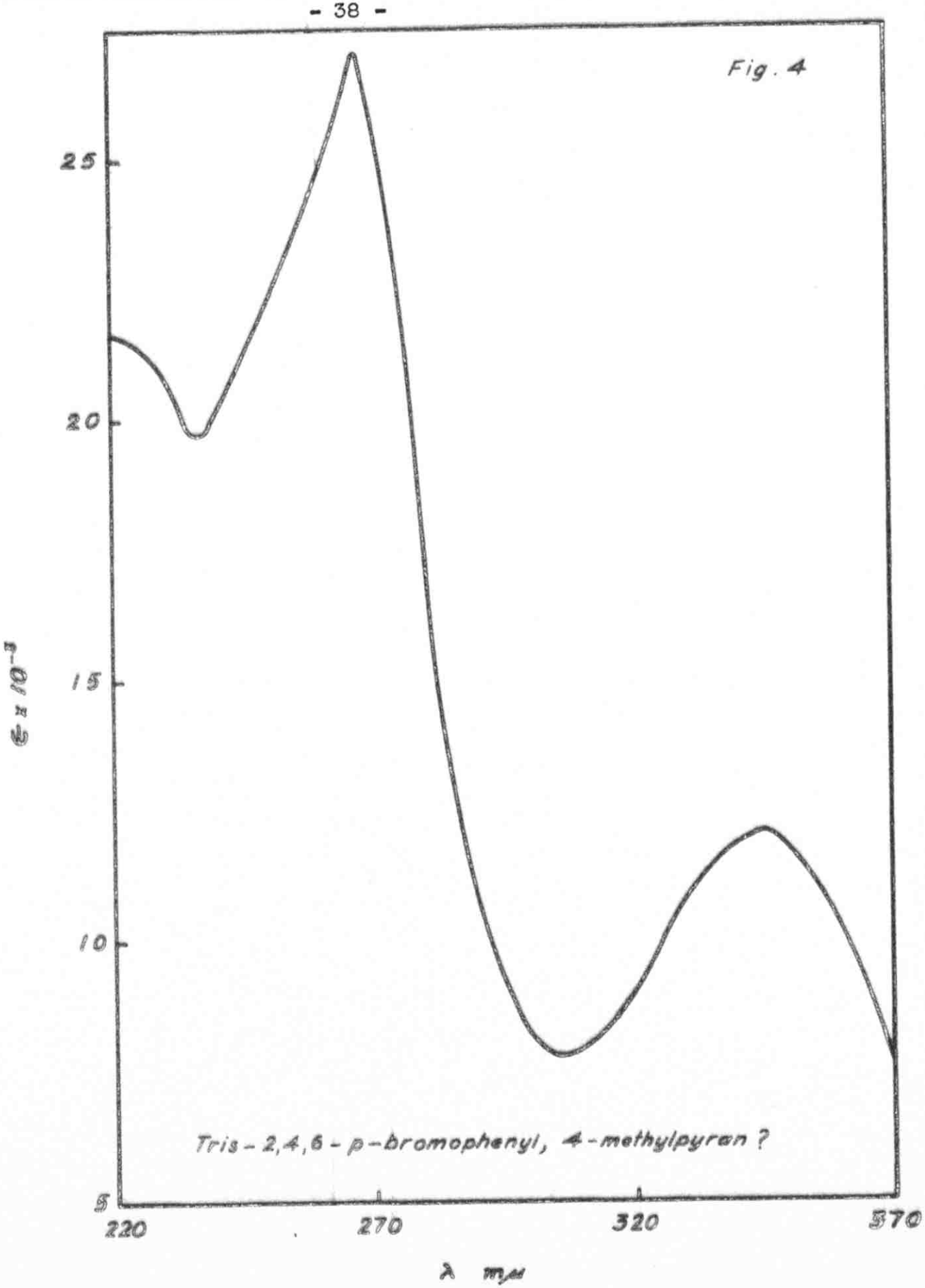
Compound (VIII) best fits the analytical data, but compound (V) cannot be ruled out on this basis. Compound (VII) fits the experimental



Tris-2,4,6-p-bromophenyl/-3-Methylpyran ?

Fig. 3

Fig. 4



Tris - 2,4,6 - p - bromophenyl, 4 - methylpyran ?

analysis least well. In short, the analytical data obtained thus far do not make possible a decision as to the structure of the compound produced in this reaction.

It was possible, however, to obtain more information concerning the structure of the unknown compound by determining its molecular weight. The molecular weight was determined, and values of 515 and 527 were found. Required for (V): 561; for (VII): 724; and for (VIII): 741. Thus it may be safe to rule out compounds (VII) and (VIII) due to the large difference between their molecular weights and the experimental value. Structure (V) is then the most probable structure for the unknown compound.

An attempt was made to synthesize the polycondensation product directly from p,p'-dibromodypnone by the usual procedure (aluminum chloride and carbon disulfide), but this attempt did not succeed. This failure constitutes negative evidence against structures (VII) and (VIII) for the polycondensation product, since both of those structures should result from the condensation of two molecules of p,p'-dibromodypnone. Thus structure (V) - which results from condensation of one molecule of the dypnone with one molecule of the acetophenone - again seems most likely as a structure for the condensation product.

The condensation of p-bromoacetophenone, using purified reagent and dried solvent, was repeated, using different concentrations of aluminum chloride. Table VII summarizes the results obtained.

Table VII

Molar ratio of $AlCl_3$ to p-Bromoacetophenone	Period of Standing	Product			
		p,pdibromodypnone	% yield(1)	Cpd. (V)	% yield(2)
0.5	7 days	traces	-	+	35
0.5(3)	7 days	+	50	+	21
0.75	12 days	-	-	-	-
0.25	4 days	+	10	-	-

(1) The yields reported in this table are only approximate.
(2) As compound (V).
(3) Purified reagents, dried solvents.

Increasing the molar ratio of aluminum chloride above 0.5 should favor formation of polycondensation products; however, even with prolonged time, the reaction did not give any products, probably because most of the p-bromoacetophenone was complexed, and the required amount of the free reagent was not available. Decreasing the molar ratio of aluminum chloride below 0.5 and shortening the time of the reaction gave only the dypnone, in greatly reduced yield; it is significant, however, that no polycondensation product was obtained, which is expected when the molar ratio of aluminum chloride to acetophenone is less than 0.5.

EXPERIMENTAL

All melting points are corrected.

All ultraviolet spectroanalyses were performed on a Beckmann Model D.U. Spectrophotometer. The solvent used is 95% ethyl alcohol, unless otherwise stated.

All infrared spectroanalyses were performed on a Perkin-Elmer Model 137 Infracord Spectrophotometer.

A. Trans-dypnone

1) Synthesis of trans-dypnone: The trans-dypnone was synthesized by the method of Calloway and Green (5). To a five-liter three-necked round-bottomed flask, fitted with an efficient stirrer and a reflux condenser protected by a calcium chloride drying tube, were added 334 gr. (2.5 moles) of anhydrous aluminum chloride, followed by 2500 cc. of rectified carbon disulfide previously dried over sodium sulfate. Acetophenone, also dried over anhydrous sodium sulfate, was then added dropwise from a dropping funnel, with stirring, until a total of 600 gr. (5 moles) of acetophenone had been added. Stirring was continued for about three hours after addition of acetophenone was complete. While adding the acetophenone, the color of the reaction mixture darkened gradually, and the formation of a dark viscous layer in the bottom of the reaction flask was observed. It was necessary to cool the flask in a water bath several times to prevent excessive reflux.

After stirring was terminated, the reaction mixture was left standing, protected by a calcium chloride tube. The color became darker, and the viscous layer mentioned above solidified.

After one week of standing, the solid cake was broken up, and the reaction mixture was hydrolyzed by pouring over 4 kgs. of crushed ice. The water layer and the carbon disulfide layer were separated using a four-liter separatory funnel. The water layer was extracted twice with carbon disulfide, using about 1300 cc. total. These extracts were combined with the original carbon disulfide layer, which was then washed twice with distilled water, using a total of 1500 cc. The combined carbon disulfide layers were finally washed once with 1200 cc of 10%

sodium bicarbonate. The carbon disulfide layer was then dried for twelve hours over anhydrous sodium sulfate.

The solvent was removed by distillation, using a water bath as a heat source. Last traces of solvent were removed under vacuum (1-2 mm.). Unreacted acetophenone was then collected at a temperature of 38°C and a pressure of 1-2 mm. Dypnone began to collect at a temperature of 150°C. at the above pressure. About 75% of the amount collected distilled in the range 150 - 155°C.; however, the distillation was continued until the temperature became 180°C.

340 gr. of dypnone were obtained as a yellow oil, corresponding to a 62% yield. (A previous preparation using undried reagents gave only 25% yield). A dark viscous residue remained in the distilling flask.

2) Physical constants of trans-dypnone: A redistilled sample boiling in the range 150 - 165°C. at 1-2 mm. pressure gave spectral data as follows:

λ_{max}, mμ: 227.5 (ϵ = 6500), 295 (ϵ = 15400).

μ: 3.48 (s), 6.10 (s), 6.35 (s), 6.85 (w), 6.98 (s), 7.89 (s), 8.50 (M), 9.52 (s), 9.72 (M), 9.95 (w), 10.48 (s), 11.45 (w, bifurcation).

The specific gravity of trans-dypnone was determined using a Fischer-Davidson gravitometer. D_4^{19} = 1.094 (average of three readings). The refractive index was measured by a Bausch and Lomb Abbe-type refractometer: n_D^{19} = 1.6338 (average of two readings). Specific refraction = 0.19; molar refraction = 42.24.

The above physical constant values compare closely with values reported in the literature. See reference (3) for a review of the published physical constant values.

3) Derivatives of Trans-dypnone:

a) p-Nitrophenylhydrazone (new compound): was prepared according to the procedure described by Shriner and Fuson (29) for the synthesis of 2,4-dinitrophenylhydrazones. Attempts to prepare it by the procedure given by the same authors for p-nitrophenylhydrazones (29) did not succeed.

A solution of p-nitrophenylhydrazine was prepared by dissolving 1.6 gr. of p-nitrophenylhydrazine in 8 ml. of concentrated sulfuric acid, followed by 12 ml. of water added dropwise, with stirring, to complete solution. To the warm solution were added 10 ml. of 95% ethanol.

A solution of trans-dypnone in ethanol was prepared by dissolving 2 gr. in 80 ml. of 95% ethanol. The freshly prepared p-nitrophenylhydrazine solution was added, and the resulting mixture was allowed to stand at room temperature. Crystallization of the new compound trans-dypnone p-nitrophenylhydrazone occurred after four minutes.

The yellow crystals obtained were recrystallized from ethanol until a constant melting point of 189 - 190°C. was obtained.

Analysis required: C, 74.00; H, 5.36; N, 11.77

Found: C, 74.39; H, 5.45; N, 11.87

λ_{max}, mμ: 230 (ϵ = 6063), and 305 (ϵ = 2611).

μ: 3.40 (s), 3.84 (w), 4.23 (M), 6.35 (s), 6.75 (s), 7.37 (s), 7.70 (s), 8.40 (M), 9.05 (s), 10.84 (M), 11.96 (s).

b) 2,4-dinitrophenylhydrazone: This compound was prepared by the same procedure described above for the preparation of the p-nitrophenylhydrazone (29). Red crystals separated which melted at 164 - 165°C. after recrystallization from absolute ethanol - ethyl acetate mixture (Literature, 173 - 174°C (3), 170°C (26).

Analysis required: C, 65.68; H. 4.47.

Found: C, 65.74; H, 4.61.

λ_{max}; mμ: 227.5 (ϵ = 6285), and 385 (ϵ = 9145).

μ: 3.12 (M), 3.40 (w), 6.35 (s), 6.70 (s), 7.10 (s), 7.55 (s), 8.85 (s), 9.05 (w), 9.85 (w), 10.89 (M), 12.00 (M).

c) Anti-phenyl oxime: was prepared by mixing 1 gr. of trans-dypnone, 1 gr. of hydroxylamine hydrochloride, 5 ml. of pyridine, and 5 ml. of absolute ethanol, and heating the mixture for two hours under reflux on a a steam bath (29). The solvents were evaporated in a current of air, and the residue was collected and recrystallized from absolute ethanol. The trans-dypnoneoxime is a colorless crystalline compound; m.p. = 132 - 133°C. (Literature, 132 - 133°C (3), 134°C. (29)).

λ_{max}; mμ: 250 (ϵ = 9088).

μ: 2.80 (M), 3.07 (s), 6.32 (M), 6.78 (M), 7.00 (s), 7.34 (w), 7.62 (w), 9.45 (w), 10.34 (s), 10.78 (s), 11.60 (w).

d) Semicarbazone: The preparation of trans-dypnone semicarbazone was unsuccessfully attempted by the method of Shriner and Fuson (29).

B. Cis-dypnone

1) Preparation of cis-dypnone: Cis-dypnone was prepared by sunlight irradiation of a 5% solution of trans-dypnone in absolute ethyl ether. The progress of the conversion was followed by spectroanalysis of the irradiated solution. The conversion required an unusually long time as compared to literature reports (3), often more than a week. Judging by the relative heights of the two peaks in the ultraviolet spectrum of the photoequilibrium mixture, at 255 mμ and 285 mμ, the conversion to cis-dypnone could

be demonstrated to proceed to an extent of 90% - 100%.

The ether was removed by a water aspirator. Ether was used as a solvent in the sunlight conversion of trans-dypnone since it could be removed by a water aspirator without resorting to heating. When 95% ethyl alcohol was used as solvent, it was necessary to use a steam bath in conjunction with a water aspirator for solvent removal. Under these conditions there was partial reconversion to trans-dypnone, as shown by the ultraviolet absorption spectrum of the remaining oil.

The cis-dypnone was stored in the freezer and was always analyzed spectrophotometrically before use, to determine whether or not reconversion had taken place.

2) Derivatives of cis-dypnone:

a) Attempted preparation of cis-dypnone p-nitrophenylhydrazone: Treatment by the procedure described above for trans-dypnone will reconvert cis-dypnone to trans-dypnone during the process, to give the derivative of the trans-isomer. Consequently the following procedure was followed: 1 gr. of cis-dypnone and 1 gr. of p-nitrophenylhydrazine were dissolved in 20 ml. of 95% ethanol and heated to the boiling temperature of ethanol. 5 drops of concentrated sulfuric acid were then added, after which crystallization followed immediately. The crystals, the nature of which is not known, were recrystallized from an alcohol-water mixture. m.p. = 160 - 161°C.

Analysis required for $C_{22}H_{19}N_3O_2$: C, 74.00; H, 5.36.

Found: C, 36.38; H. 4.23.

λ_{max}; mμ: 230 and 382.5.

μ: 3.55 (s), 4.20 (w), 4.97 (M), 5.14 (s), 6.80 (s), 7.50 (s), 7.80 (s), 10.71 (s), 11.85 (s).

b) 2,4-dinitrophenylhydrazone: This preparation was carried out according to the procedure described in Shriner and Fuson (29). A pink crystalline material was obtained which melted over a wide range. Upon treatment with 95% ethanol, part of it dissolved (fraction 1), and a residue was left (fraction 2). Fraction 1 was recrystallized from ethanol to yield pink crystals which melted at 141 - 143°C.

Analysis required: C, 65.68; H, 4.47; N, 13.93.

Found: C, 65.69; H, 4.66; N, 14.12.

λ_{max}; mμ: 385 (ϵ = 12898).

μ: 3.28 (s), 3.56 (w), 6.30 (s), 6.70 (s), 7.00 (s), 8.78 (s), 9.08 (w), 9.65 (w), 10.74 (M), 11.91 (M).

Fraction 2 was washed again with alcohol and dried. It melted at 209 - 211°C. A small sample of it was recrystallized from absolute alcohol-ethyl acetate mixture to give a melting point of 212.5 - 213.5°C.

Analysis required: C, 65.68; H, 4.47.

Found: C, 65.63; H, 4.76.

λ_{max}; mμ: 225 (ϵ = 10764) and 387 (ϵ = 12092).

μ: 2.92 (w), 3.22 (w), 6.10 (s), 6.20 (s), 6.55 (s), 6.98 (M), 7.48 (s), 7.60 (s), 8.82 (s), 9.06 (w), 11.05 (w), 12.14 (M).

c) Anti-phenyl oxime: The attempted synthesis of cis-dypnone oxime was unsuccessful. The procedure was that of Shriner and Fuson (29).

d) Semicarbazone: Its attempted synthesis was also unsuccessful. The procedure was that of Shriner and Fuson (29).

C. Organometallic reactions

All the reactions which will be described under this heading were

performed under a nitrogen atmosphere. Nitrogen gas was purified by passing it consecutively through potassium hydroxide pellets, concentrated sulfuric acid, and drierite, before it entered the reaction flask. The nitrogen gas was allowed to flush out the reaction flask for a sufficient time to drive off the air before any of the reactants was added.

1) Reactions of trans- and cis-dypnones with phenylmagnesium bromide: Phenylmagnesium bromide was prepared according to the directions of Fieser (30). A 500 cc. three-necked round-bottomed flask was used. It was fitted with a condenser (at the top of which was placed the nitrogen gas inlet), a dropping funnel with a pressure equalizing side arm, and a stirrer, the shaft of which passed through a mercury seal to render the flask air-tight.

2.50 gr. (0.1 mole) of magnesium metal chips were introduced into the flask, followed by a solution of 16 gr. (0.1 mole) of bromobenzene in 75 ml. of dry ether, added dropwise through the dropping funnel, with stirring. A crystal of iodine was added to start the reaction, after which the ethereal solution boiled gently due to the heat produced.

The procedure of Freeman (23) was used in the addition of dypnone to phenylmagnesium bromide. After the addition of the bromobenzene solution was completed, an additional 50 ml. of dry ether were introduced, followed by a solution of 11 gr. (0.05 mole) of dypnone in 50 ml. of dry ether, added dropwise.

After the spontaneous reaction was over, the nitrogen gas line was disconnected (the nitrogen stream carried off the solvent quickly), and the condenser was fitted with a calcium chloride tube. The reactants were refluxed for an additional four hours with continuous stirring.

The reaction mixture was then hydrolyzed by pouring into a mixture of ice and hydrochloric acid. After four hours of standing, the organic layer was separated, and the water layer extracted with two 100 ml. portions of ether. The extracts were combined with the original ethereal layer, and the combined ethereal layer was dried over anhydrous sodium sulfate for twelve hours.

The solvent was removed under reduced pressure, applying no heat. An orange oil was left which dissolved in hot ethyl alcohol. Cooling the solution in the freezer caused a yellow oil to separate. The alcoholic solution was decanted, and the oil was left in the cold for two weeks.

The alcoholic solution was concentrated and then cooled to yield colorless crystals of β,β-diphenylbutyrophenone. These crystals were recrystallized from 95% ethyl alcohol and gave m.p. 97 - 99°C. (Literature 99 - 102°C. (23) this value is not listed as corrected).

λ_{max}; mμ: 242.5 (ϵ = 14688).

μ: 3.50 (s), 6.05 (s), 6.40 (M), 6.80 (w), 7.00 (M), 7.50 (s), 8.55 (w), 8.85 (w), 10.00 (M), 11.00 (w).

After two weeks of standing in the cold, the yellow oil was treated with boiling alcohol and a few drops of benzene. The impurities which caused the sluggishness in crystallization dissolved to leave a crystalline hydrocarbon, 1,1,3-triphenyl-1,3-butadiene. This product was recrystallized from 50-50 ethanol-benzene mixture to give colorless crystals melting at 160 - 162°C. (Literature, 163°C. (24), 165 - 166°C. (23); the latter value is not listed as corrected).

λ_{max}; mμ: 252.5 (ϵ = 13109). (Literature, 252 (ϵ = 16000 (23).

μ: 3.50 (s), 6.35 (M), 6.78 (s), 7.00 (M), 9.30 (w), 11.10 (w).

Trans-dypnone gave 5.4 gr. of β,β-diphenylbutyrophenone, corresponding to 36% yield, and 3.5 gr. of 1,1,3-triphenyl-1,3-butadiene, corresponding to 24.8% yield.

Cis-dypnone gave 1.4 gr. of the β,β-diphenylbutyrophenone, corresponding to 9.3% yield, and 0.85 gr. of the 1,1,3-triphenyl-1,3-butadiene, corresponding to 5.9% yield. A mixed melting point determination of the samples of β,β-diphenylbutyrophenone from both trans- and cis-dypnone gave no depression (m.p. 97 - 99°C.). A mixture melting point determination on the samples of 1,1,3-triphenyl-1,3-butadiene from the dypnones likewise showed no depression (m.p. = 160 - 162°C.). The ultraviolet spectra of samples of the same compound from the two reactions were identical, as were the infrared spectra.

2) Reaction of dypnone with phenyllithium: Lithium blocks were drawn into wires by using a press and were stored in a flask containing paraffin oil. This flask was provided with a stopcock at the bottom to drain off the oil whenever the lithium metal was to be used. The lithium wires were washed with dry benzene and dry ether before use. Several 10 cm. pieces of the wire were weighed and their weights averaged, so that any required weight of lithium metal could be handled by cutting the necessary length of the wire.

The phenyllithium was prepared according to the method of Fieser (30). A 1000 cc. three-necked round-bottomed flask was thoroughly dried. It was provided with a condenser, (at the top of which was fitted the nitrogen gas inlet) a dropping funnel with a pressure equalizing side arm, and a stirrer, the shaft of which passed through a mercury seal to render the flask airtight.

4.2 gr. (0.6 gr. atom) of lithium metal, in the form of short pieces of wire, were introduced into the flask, followed by 47 gr. (0.3 mole) of bromobenzene in 300 ml. of dry ether, added dropwise through the dropping funnel. The reaction began spontaneously, and the solvent refluxed continuously during the period of addition. The stirring of the phenyllithium solution was continued, and, after the reaction had subsided, a solution of 33.5 gr. (0.15 mole) of dypnone in 150 ml. of dry ether was added dropwise, according to the procedure of Freeman (23). The reaction mixture boiled vigorously during the addition. After disconnecting the nitrogen gas line and protecting the reactants with a calcium chloride tube fitted on the top of the reflux condenser, the reaction mixture was refluxed for an additional four hours.

The product of this reaction is dependent upon the method of hydrolysis. Two hydrolyzing media were used: hydrochloric acid, or ammonium chloride.

a) Hydrochloric acid hydrolysis: The method is that of Freeman (23). The ethereal layer was poured onto a mixture of ice and hydrochloric acid and allowed to stand for four hours. Layers were then separated; the aqueous layer was extracted twice with 150-ml. portions of ether, and these extracts were combined with the original ethereal layer, which was then dried over anhydrous sodium sulfate for twelve hours. The solvent was then distilled off under reduced pressure, without heating. A thin yellow oil remained which was left in the cold for two weeks. After this period the oil was treated with boiling alcohol and a little benzene; it yielded finely divided crystals which were recrystallized from 50-50

benzene-ethanol mixture to give a melting point of 160 - 162°C. (Literature, 163°C. (24), 164 - 167°C. (23), the latter value not specified as corrected).

Trans-dypnone gave 15.2 gr. of the product, corresponding to a 36% yield of the hydrocarbon 1,1,3-triphenyl-1,3-butadiene. Cis-dypnone gave 12 gr., corresponding to 28.6% yield.

A mixed melting point determination on the products from trans- and cis-dypnone in the above reaction showed no depression (m.p. 160 - 162°C.). Similarly, neither of these products showed any depression of melting point on admixture with the sample of 1,1,3-triphenyl-1,3-butadiene obtained from the reaction of trans-dypnone with phenylmagnesium bromide (mixture m.p. 160 - 162°C.).

The ultraviolet spectra of the products from trans- and cis-dypnone were identical to each other and to the ultraviolet spectrum of 1,1,3-triphenyl-1,3-butadiene obtained from the reaction of trans-dypnone with phenyl Grignard reagent. The infrared spectra of the two samples were similarly identical.

b) Ammonium chloride hydrolysis; preparation of 1,1,3-triphenylbut-2-ene-1-ol: The method used is essentially that of Freeman (23). The ethereal solution was poured into a solution of 50 gr. of ammonium chloride in a water-ice mixture. After standing for four hours, the organic layer was separated and dried as described above for the hydrochloric acid hydrolysis. After evaporating off the solvent by reducing the pressure, a pink oil remained, the infrared spectrum of which showed a characteristic hydroxyl group absorption, and which reacted vigorously with acetyl chloride. This oil was dissolved in benzene and left in the

cold for two days, during which time a colorless crystalline compound separated. After three weeks of standing another minor crop was obtained. The crude material melted in the range 73 - 79°C. It was washed with petroleum ether and then recrystallized from a petroleum ether-alcohol mixture to yield a product of melting point 85 - 86°C.

Analysis required: C, 87.96; H, 6.71.

Found: C, 87.90; H, 6.63.

λ_{max}; mμ: 247.5 (ϵ = 13708 (product from trans-dypnone).

ϵ = 13723 (product from cis-dypnone).

μ: 2.78 (M), 3.35 (M), 6.51 (M), 7.00 (s), 7.20 (s), 7.95 (M), 8.95 (M), 10.01 (w), 10.30 (s), 11.70 (M).

Trans-dypnone produced 17.1 gr. of the above carbinol, corresponding to 38% yield, and cis-dypnone gave 13.1 gr., corresponding to 29.1% yield. The mixed melting point of the two samples of carbinol obtained from the above isomers showed no depression (m.p. = 85 - 86°C), and their ultraviolet spectra were identical, as were their infrared spectra.

A sample of the carbinol was dissolved in ether, mixed with an ice-hydrochloric acid mixture, and left for sixteen hours. The ether layer was then separated, combined with ether extracts of the water layer, and dried over sodium sulfate for twelve hours. After removal of the solvent a yellow oil was left, which, after standing in the cold for two weeks, was treated with hot ethyl alcohol and a little benzene. A colorless crystalline compound resulted, which, after recrystallization from ethyl alcohol-benzene mixture, melted at 157 - 160°C. A mixture of the above compound and 1,1,3-triphenyl-1,3-butadiene (m.p. 160 - 162°C.) melted at 159 - 161°C. The identity of this compound with 1,1,3-triphenyl-1,3-butadiene was further shown by the identity of their ultraviolet spectra.

D. Synthesis of p,p'-disubstituted dypnones

1) Attempted synthesis of p,p'-N,N-dimethylaminodypnone: p-N,N-dimethylaminoacetophenone was synthesized using Nineham's procedure (31). To 1500 gr. of redistilled N,N-dimethylaniline in a five-liter, three-necked round-bottomed flask were added 375 gr. of phosphorous pentoxide and 20 gr. of "celite". 300 gr. (5 moles) of glacial acetic acid were then added dropwise with continous stirring. After a reflux period of one hour, the reaction mixture was poured onto ice and made alkaline with sodium hydroxide.

The reaction mixture was then extracted several times with 200-ml. portions of benzene; the benzene extracts were washed with water and then dried over sodium sulfate.

The solvent was removed under reduced pressure using a water aspirator. Unreacted N,N-dimethylaniline distilled at a temperature range of 90 - 100°C. The product began to distil at a temperature of 150°C. at 1-2 mm. pressure, but the distillation proceeded very slowly and inefficiently. The distillation was stopped, and the product was extracted from a viscous dark oil by hot petroleum ether (b.p. 50 - 70°C.). 160 gr. of the product, were obtained. It melted at 95 - 100°C., and at 98 - 100°C. after one recrystallization from petroleum ether. (Literature, 104 - 105°C. (3), 103 - 103.5°C. (31). The yield was 20%.

λ_{max}; μ: 3.41 (s), 6.05 (s), 6.30 (3), 6.81 (s), 7.40 (s), 7.85(s), 8.16 (s), 8.49 (s), 9.38 (M), 10.08 (M), 10.61 (s).

12 gr. (0.074 mole) of this p-N,N-dimethylaminoacetophenone were dissolved in dry carbon disulfide. This solution was added dropwise to 4.95 gr. (0.037 mole) of aluminum chloride in 50 cc. carbon disulfide, with

stirring. After nine days of standing the reaction mixture was hydrolyzed with an ice-water mixture as described under the synthesis of dypnone. A total of 9 gr. (75%) of the starting material (m.p. 96 - 100°C., infrared spectrum identical to that of p-N,N-dimethylaminoacetophenone) was recovered, and no condensation product was obtained.

2) Attempted preparation of p,p'-dimethoxydypnone; tris-1,3,5-p-methoxyphenylbenzene: 256 gr. (1.71 mole) of p-methoxyacetophenone were dissolved in carbon disulfide previously dried over phosphorous pentoxide. This solution was then added dropwise, with stirring, to 114 gr. (0.855 mole) of aluminum chloride in 100 ml. carbon disulfide. Stirring was continued for seven hours, after which the reaction was left to stand for fourteen days.

The reaction mixture was hydrolyzed in a water-ice mixture. The carbon disulfide and water layers were then separated, and the carbon disulfide layer was dried over sodium sulfate (see synthesis of trans-dypnone).

After the solvent was removed on a water bath (last traces under vacuum), an oil was left which, on cooling, formed a gel. The oil was then dissolved in alcohol, and, after standing at room temperature, 13 gr. of a product which melted at 137 - 140°C. were collected. After cooling the alcohol solution, crystals which melted at 33 - 37°C. were obtained. The starting material melts at 38°C., and the infrared spectrum of these crystals is identical to that of the p-methoxyacetophenone, the starting material. The recovery of starting material came to 80%.

The relatively pure product, m.p. 137 - 140°C., does not dissolve in alcohol. It was recrystallized from an ethyl alcohol-chloroform mixture. The pure compound melts at 142 - 143°C. (Literature, 143°C. (17)). The yield is 9%.

Analysis required: C, 81.79; H, 6.10.

Found: C, 81.18; H, 6.10.

λ_{max}; mμ: 267.5 (ϵ = 90200).

μ: 3.38 (M), 3.56 (M), 4.40 (w), 6.20 (s), 6.62 (s), 6.96 (s), 7.20 (M), 7.80 (s), 8.00 (s), 8.50 (s), 9.00 (M), 9.70 (s), 11.39 (M), 12.10 (s).

3) Synthesis of p,p'-dibromodypnone: 199 gr. (1 mole) of p-bromoacetophenone was dissolved in 500 cc. of carbon disulfide and added dropwise to 66.5 gr. (0.5 mole) of aluminum chloride in carbon disulfide, with stirring. After seven days' standing the solidified reaction mixture was crushed and hydrolyzed with ice. The organic layer and the aqueous layer were then separated, and the organic layer was dried over sodium sulfate. (Details of the procedure, and description of the apparatus used are described under synthesis of dypnone).

After distilling off the solvent using a water bath, an oily residue remained which crystallized upon cooling but which did not show a sharply defined melting point because of impurities. After washing with petroleum ether, the product melted at 89 - 104°C. Recrystallization from ethyl alcohol was attempted, but only a small fraction dissolved. The residue left melted at 128 - 130°C.

The alcohol solution upon cooling yielded a first crop of crystals which melted at 128 - 130°C. (Mixed melting point with the residue mentioned above showed no depression; m.p. = 128 - 130°C.). The alcohol solution was then concentrated and cooled. A small quantity of crude p,p'-dibromodypnone separated as a second crop. Recrystallizations from alcohol did not improve the melting point.

The compound melting at 128 - 130°C. was recrystallized from an alcohol - chloroform mixture, finally giving m.p. = 133 - 134°C.

Results of elementary analysis are summarized in table VI in the theoretical discussion of this thesis.

λ_{max}; mμ: 267.5 (ϵ = 27041), 345 (ϵ = 12018).

μ: 3.56 (w), 550 (w), 6.29 (s), 6.49 (s), 6.90 (s), 7.30 (S), 8.00 (w), 8.64 (w), 9.40 (s), 9.98 (s), 10.48 (w), 12.16 (s).

Molecular weight required for 2,4,6-tris-p-bromophenyl, 4-methyl-pyran (designated as compound (V) in the theoretical discussion) = 561. Found: 515, 527 (double determination).

The condensation of p-bromoacetophenone was repeated under the same set of conditions described above, using carefully purified and dried reagents. On this trial p,p'-dibromodypnone was produced; melting point 104 - 105°C. After recrystallization from absolute ethanol (Literature, 104 - 105°C. (3)). The yield was 50%.

λ_{max}, μ: 3.29 (M), 6.01 (s), 6.26 (s), 6.71 (M), 6.29 (w), 7.12 (M), 7.82 (s), 8.50 (M), 9.34 (s), 9.52 (M), 9.90 (s), 10.55 (w), 12.23 (s).

This reaction mixture also gave a 21% yield (as the pyran) of the compound melting at 133 - 134°C.

The condensation of p-bromoacetophenone was also repeated under varying sets of conditions; the effect of changing the aluminum chloride concentration, and of changing the period of standing of the reaction mixture, was studied. The results of these condensations, and of preceding condensations of p-bromoacetophenone discussed above, as to the nature

of the products obtained and percentage yields, are summarized in table VII in the theoretical discussion of this thesis. The experimental details of these reactions are as outlined above except for the varying concentrations of aluminum chloride and varying reaction times.

4) Attempted condensation of p,p'-dibromodypnone: 38 gr. (0.1 mole) of p,p -dibromodypnone were dissolved in carbon disulfide which had been dried over phosphorous pentoxide, and this solution was then added dropwise, with stirring, to 6.7 gr. (0.05 mole) of aluminum chloride in 50-ml. of dry carbon disulfide (see synthesis of trans-dypnone for details). Evolution of hydrogen chloride was not noticed, and the reaction mixture did not become hot. The reaction mixture was left standing for twelve days, after which time it was worked up as described under synthesis of trans-dypnone. After distilling the solvent over a water bath (last traces under vacuum), 35 gr. (92%) of the starting material were recovered (m.p. 101 - 103°C.), and no condensation product was obtained. A mixture melting point between this recovered material and the starting material showed no depression (m.p. = 102 - 104°C.).

SUMMARY

Condensation of acetophenone to trans-dypnone was effected by aluminum chloride in carbon disulfide. The trans-dypnone was characterized by the determination of its physical properties. Trans-dypnone p-nitrophenylhydrazone (a new compound), 2,4-dinitrophenylhydrazone, and anti-phenyl oxime were prepared.

Cis-dypnone was prepared by sunlight irradiation of trans-dypnone, and the cis-dypnone-2,4-dinitrophenylhydrazone was prepared. Two polymorphic forms were obtained. The product of the reaction with p-nitrophenylhydrazine was not identified.

Addition of phenylmagnesium bromide to trans-dypnone followed by acid hydrolysis gave the 1,4-adduct, β,β-diphenylbutyrophenone, in 36% yield, and the 1,2-adduct, 1,1,3-triphenyl-1,3-butadiene, in 25% yield. Corresponding yields of 9.3% 1,4-product and 5.9% 1,2-product were obtained in the case of the cis-isomer.

The final product of phenyllithium addition to dypnone was dependent on the method of hydrolysis of the intermediate. Acid hydrolysis gave only 1,1,3-triphenyl-1,3-butadiene; 36% yield from trans-dypnone, and 28.6% yield from cis-dypnone. Mild hydrolysis with ammonium chloride gave only 1,1,3-triphenylbut-2-ene-1-ol (new compound); 38% yield from trans-dypnone, and 29% yield from cis-dypnone.

These results from the organometallic additions to trans- and cis-dypnones show the decreased reactivity of the dypnones as compared to the chalcones, towards 1,4-attack, due to the steric hindrance of the β-methyl group. Cis-dypnone gives lower overall yields, since it provides steric

hindrance to both 1,2- and 1,4-addition. The carbinol has been shown to be 1,1,3-triphenylbut-2-ene-1-ol rather than its allylic rearrangement product.

Attempted condensation of p-N,N-dimethylaminoacetophenone to the corresponding dypnone was unsuccessful. Condensation of p-methoxy-acetophenone gave only tris-1,3,5-p-methoxyphenylbenzene, in 9% yield. This lack of success in obtaining p,p'-di-N,N-dimethylaminodypnone and p,p'-dimethoxydypnone is to be expected in view of the electron-donating character of the p-N,N-dimethylamino group and the p-methoxy group on the acetophenone starting materials; the acetophenone carbonyl group becomes less polarized, and thus less active towards the Aldol-type reaction by which the dypnones are formed. Condensation of p-bromoacetophenone (p-bromo atom is electron with-drawing) gave 50% of the expected dypnone and 21% of what is tentatively assigned the structure of tris-2,4,6-p-bromophenyl-4-methyl-pyran. The effect of varying the aluminum chloride concentration and the reaction period was also studied in the latter condensation. It was found that the optimum concentration of aluminum chloride was 0.5 mole for every mole of the acetophenone; short reaction time favored formation of the dypnone, while long reaction time favored further condensation.

BIBLIOGRAPHY

1.- M. Delacre, Bull. Acad. Roy. Belgique (3), 20, 466 (1890). (F.K. Beilstein, Handbuch der organischen chemie (4th edition, 1925), VII, 485).

2.- E.P. Kohler, Am. Chem. J., 31, 642 (1904). (L.T. Slade, M.S. Thesis, University of Virginia, 1958).

3.- L.T. Slade, M.S. Thesis, University of Virginia, 1958.

4.- J.F. Eijkman, Chemisch weekblad, 1, 349 (1904). (Chem. Zentr., 1904, I, 1258). (L.T. Slade, M.S. Thesis, University of Virginia, 1958).

5.- N.O. Calloway and L.D. Green, J. Am. Chem. Soc., 59, 809 (1937).

6.- L.I. Smith and W.B. Pings, J. Org. Chem., 2, 23 (1937).

7.- H. Adkins and F.W. Cox, J. Am. Chem. Soc., 60, 1151 (1938).

8.- W. Wayne and H. Adkins, ibid., 62, 3401 (1940).

9.- W. Wayne and H. Adkins, Organic Syntheses, Coll. vol. III, E.C. Horning, editor in chief, John Wiley and Sons, Inc., New York, New York, 1955, pp. 367 - 69.

10.- A.R. Bader, (to Pittsburgh Plateglass Company) U.S. pat., 2, 769, 842, Nov. 6, 1956. (Chemical Abstracts, 52, 439^{f} (1958)).

11.- G. Reddelien, Ann., 388, 165 (1912). (Chemical Abstracts, 6, 1597 (1912)).

12.- G. Illari, Gazz. Chim. Ital., 77, 492 (1947). (Chemical Abstracts, 42, 3357^{h} (1948)).

13.- J.H. Simons and E.O. Ramler, J. Am. Chem. Soc., 65, 1390 (1943).

14.- C.R. Hauser and W.H. Puterbaugh, ibid., 75, 4756 (1953).

15.- D. Ivanov and T. Ivanov, Ber., 76, 988 (1943).

16.- E.C. Dodds, R.L. Huang, W. Lawson, and R. Robinson, Proc. Roy. Soc. (London), B140, 470 (1953).

17.- R.E. Lyle, E.J. Dewitt, N.M. Nichols, and W. Cleland, J. Am. Chem. Soc., 75, 5959 (1953).

18.- H. Gilman and R.H. Kirby, ibid., 63, 2046 (1941).

19.- I.S. MacClean and T.S. Widdows, J. Chem. Soc., 105, 2169 (1914). (Chemical Abstracts, 9, 199 (1915)).

20.- R.E. Lutz and E.H. Rinker, J. Am. Chem. Soc., 77, 366 (1955).

21.- R.E. Lutz and J.O. Weiss, ibid., 77, 1814 (1955).

22.- E.P. Kohler, Am. Chem. J., 38, 511 (1907). (L.T. Slade, M.S. Thesis, University of Virginia, 1958).

23.- J.P. Freeman, J. Org. Chem., 22, 1608 (1957).

24.- K. Ziegler and W. Sauermilch, Ber., 63B, 1851 (1930).

25.- C.F. Koelsch and P.R. Johnson, J. Am. Chem. Soc., 65, 567 (1943).

26.- G. Martin, Compt. Rendu, 245, 1933 (1957). (Chemical Abstracts, 57, 8945^{f} (1958)).

27.- F.J. Wilson and R.M. Macaulay, J. Chem. Soc., 125, 841 (1924). (Chemical Abstracts, 18, 2154 (1924)).

28.- H. Stobbe and L. Bremer, J. Prakt. Chem. (2), 123, 1 (1929). (Chemical Abstracts, 24, 92 (1930).

29.- R.L. Shriner, R.C. Fuson, and D.Y. Curtin, The Systematic Identification of Organic Compounds, fourth edition, John Wiley and Sons, Inc., New York, New York, 1959.

30.- L.F. Fieser, Experiments in Organic Chemistry, Third edition, D.C. Heath and Company, Boston, Massachusetts, 1955.

31.- A.W. Nineham, J. Chem. Soc., 1952, 635.