Synthesis of Para-Hydroxy 1-1, Diphenylbutane by means of Aluminum Chloride and the Preparation of Ortho-Hydroxy 1-1, Diphenylbutane and 1 - Phenylbutylphenylether.

THESIS

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By

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INTRODUCTION

Aluminum chloride as a means of effecting chemical change has had an extensive and remarkably varied application in organic chemistry. It has been the subject of a vast amount of research every since Friedel and Crafts first proposed using it in obtaining condensation products. It has been instrumental in adding to our knowledge whole classes of bodies of the most diverse kinds.

Syntheses accomplished by means of aluminum chloride almost invariably give considerable quantities of resinous or gummy products. More than one group is generally introduced. The monosubstitution products together with a mixture of higher substitution products being simultaneously formed. They, however, can usually be separated by fractional distillation.

The catalytic influence of aluminum chloride is not definitely understood, although many theories have been advanced attempting to explain it, i.e., intermediate aluminum organic compounds which different workers have isolated(1). On the other hand, the action of aluminum chloride is frequently much more complicated, inasmuch as we also find decompositions, splitting off, internal condensations, transference of the alkyls as well as the formation of synthetic products. A tabulation of references to some of the complex reactions follows:

(2) Annalen 235 : 150 - 229

(3) Annalen Chim. Phys. (6) I,449

(4) Carbon Compounds - Porter, page 421

(5) Chemical Reactions - Falk, page 103

(6) Organic Chemistry - Cohen, Vol. I, page 195

James F. Norris[7] thinks that aluminum chloride plays the role of a true catalyst in cases where no aluminum addition compounds exist. Quoting from his article, "A molecular attraction exists, which results from residual affinities. Two molecules when brought together must exert an influence one on the other, and this must result in a change in the attractions between the atoms within each molecule. Solvents have a marked effect on the rate at which a given reaction proceeds. From the foregoing point of view they act as true catalysts by altering the strength of affinities between atoms in the molecule. When changes set up in the affinities lead to increased reactivity the added substance is a positive catalyst. If on the other hand, the reactivity is reduced, the substance functions as a negative catalyst".

Thus it is seen that there is considerable work yet to be done in which aluminum chloride is used as an agent in bringing about chemical changes in organic reactions. The present investigation was conducted to ascertain the products obtained by condensing propylphenylcarbinol and phenol by means of aluminum chloride (in which there occurs dehydration) and also to determine if Friedel and Crafts method could be employed in preparing the same compound, since it appears they encountered difficulty in such condensations[8].

It might further be stated that a comparative study of the quantities and products obtained by the above methods of synthesis may later lead to a clearer understanding of the reactions involved.

HISTORICAL RESUME

1. Early Investigations of Aluminum Chloride.

Thirty-seven years prior to Friedel and Crafts observation that aluminum chloride could be used as an effective method of synthesis, Kuhlmann found that aluminum chloride could be used in preparing ethers.

In 1840 Kuhlmann(9) (Untersuchungen uber die Aetherbildung) prepared a number of ethers by the action of anhydrous metal chlorides on mixtures of alcohols. Aluminum chloride is given as one of the metal chlorides used.

It was early observed that aluminum dust served as a very effective catalyst in decomposing solutions of certain halogen aliphatic compounds. In 1876 M. M. Gladstone and Tribe(10) published two articles entitled, "Decomposition of Solutions by Aluminum in the Presence of its Halogen Compounds". In these articlesthey recommended the use of a small amount of the chloride, bromide or iodide of aluminum in preference to zinc or zinc-copper couple in obtaining decomposition products of alcohols.

The following year Friedel and Crafts(11) communicated their experiences relative to the action of aluminum chloride onthe hydrocarbon chlorides, notably on amyl chloride. They found that when a cold solution of amyl chloride and aluminum chloride were allowed to react, a vigorous reaction took place in which HCl was liberated, "and the combustible gases form saturated condensation products which do not absorb bromine". They found that the principle hydrocarbon formed consisted of the general formula C_nH_{2n+2}, which indicated the formation

of a different hydrocarbon of the same group. When Friedel and Crafts employed this method in the presence of aromatic compounds they were able to synthesize homologues of benzene. The employment of aluminum chloride has come to be termed in organic chemistry, "Friedel and Crafts Reaction", and the salt, "Friedel and Crafts Reagent". It appears that Friedel and Crafts encountered difficulty when they applied their procedure to alcohols and phenols. Quoting from Friedel and Crafts publication(8) "We found in general that compounds containing the group OH or OR, i.e., alcohols, phenols, acids and their ethers undergo decomposition with chloride of aluminum and the reactions which we have described are usually impossible in the presence of such bodies".

2. Early Investigations of Phenol Condensations in Which Dehydration Occurs.

A number of important condensations have been effected by the union between molecules with the elimination of water, but prior to 1914 the chief dehydrating agents consisted of concentrated sulfuric acid, acetic anhydride, zinc chloride, phosphorus pentaoxide, hydrochloric acid and occasionally by heating to high temperatures.

In 1871 Aldolf Baeyer[13] (Über die Phenolfarbstoffe) condensed two molecules of phenol with one molecule of phthalic anhydride in the presence of concentrated sulfuric acid. The following year Baeyer[13] showed that benzaldehyde and phenol could be condensed by using concentrated sulfuric acid which eliminated water. Many other condensations are cited in this article. Thirty years later he[14] showed that triphenylcarbinol and phenol will react in the presence of glacial acetic acid and concentrated sulfuric acid to give para hydroxy tetraphenylmethane and water.

Auer[15] found that phenol and absolute alcohol gave ethyl phenol in the presence of zinc chloride. Merz and Weith[16] have shown that aluminum chloride acts upon phenol to give diphenylether. Mazzara[17] condensed isobutyl alcohol and phenol with magnesium chloride and obtained isobutylphenol (with the elimination of water). He also records obtaining a substance insoluble in potash and supposes it to be the corresponding isobutylic ether.

Ipat'ev, Orlov and Petrov[18] have recently shown, that phenol and methyl alcohol will react to give ortho cresol,

methylphenylether together with xanthene and other by products. They used $Al(OH)_3$ and heated the mixture under pressure.

3. Condensation of Aromatic Alcohols in Which Water is Eliminated.

In 1873 V. Meyer and Wurster[19] showed the first possibilities of condensing aromatic alcohols with aromatic hydrocarbons. They used sulfuric acid as a dehydrating agent with which they condensed benzyl alcohol and benzene to diphenylmethane, according to Baeyer's aldehyde synthesis.[13]. They also report finding some by-products of high boiling point.

Hemilian[20] found benzhydrol (a secondary aromatic alcohol) could be condensed with benzene in the presence of phosphorus pentaoxide to give triphenylmethane and water. He[21] also found that fluorenyl alcohol and benzene gave water and diphenylene-phenylmethane. When toluene was substituted for benzene diphenylene-tolylmethane and water were formed.

Seven years later Ad. Liebman[22] (Synthese der Homologen Phenole) was successful in condensing isobutylalcohol, amylalcohol and benzylalcohol with phenol by using zinc chloride. Senkowski[23] and Anschutz[24] later showed that the condensation products obtained by Liebman belonged to the para series.

The following year Liebman[25] reinvestigated his previous work and found that small amounts of ethers were obtained in the condensation reactions. He was also successful in condensing benzyl chloride and phenol with zinc chloride. Reactions in which Friedel and Crafts encountered difficulty with aluminum chloride[8].

Fischer[26] found that by using zinc chloride, dehydration occurred when benzyl alcohol or diphenylcarbinol was condensed with dimethylaniline.

4. Aluminum Chloride as a Dehydrating Agent.

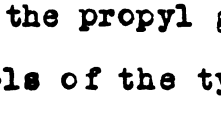
In 1881 Merz and Weith(16) found that aluminum chloride exhibited dehydration properties similar to zinc chloride. They found that phenol and aluminum chloride would react at 300° to give benzene, diphenylether and methylene-diphenyl oxide. Graebe(27) in 1901 showedthat aluminum chloride was capable of effecting dehydration between a mixture of benzene and hydroxylamine with the formation of aniline.

It appears that no further investigations were conducted in regard to the dehydration properties of aluminum chloride until in 1914 when Frankforter(28) and his co-workers published two articles in which they found condensation occurred with the elimination of water when chloral bromal, trioxymethylene and chloral hydrate were allowed to react with certain organic compounds. In 1915(29) they published another article in which they extended their investigations to the polycyclic hydrocarbons.

Huston and Friedeman(30) were the first to investigate the dehydration properties of aluminum chloride upon mixtures of aromatic alcohols and aromatic compounds. In these investigations they have outlined a very important method for the preparation of synthetic compounds.

In 1918(31) they extended their investigations to experiments including the action of secondary alcohols on benzene, i.e., benzhydrol (a true secondary aromatic alcohol) methylphenylcarbinol and ethylphenylcarbinol (mixed aromatic aliphatic alcohols) in which they obtained triphenylmethane, diphenylethane and diphenylpropane respectively. They found a

larger yield and smoother reaction was obtained with benzhydrol than with methylphenylcarbinol and ethylphenylcarbinol, the later having the greatest retarding effect. Hence they concluded the longer the parafin chain the more retarding effect it exhibits. In 1924 Huston(32) found that benzyl alcohol and phenol would condense in the presence of aluminum chloride to give parabenzylphenol and that the phenolic hydroxyl group does not interfere with the substitution of the benzyl group in the benzene ring under the described conditions.

The present work, as stated in the introduction, has consisted of an investigation of the condensation obtained when aluminum chloride is allowed to act upon a mixture of propylphenylcarbinol and phenol. The condensation will also show the effect which the propyl group maintains in mixed secondary aromatic alcohols of the type  when they are condensed with phenol. The methyl and ethyl compounds have been investigated by Huston and his co-workers(33).

III Experimental

1. Preparation of Propylphenylcarbinol.

Propylphenylcarbinol can be conveniently prepared in excellent yield by means of the Grignard Reaction. The best results are obtained when heat is not applied and particularly by controlling the relative proportion of the reactants. Ethylphenylcarbinol has been recently investigated by Meisenheimer[34] He found that the best results could be obtained when the Grignard reagent and the benzaldehyde were in the proportion 3 : 2, otherwise large quantities of benzyl alcohol and high boiling by-products are obtained.

Rheinboldt and H Roleff[35] (Reducing Action of Organo-Magnesium Halides) showed that the reduction of Grignards reagent increases greatly with rise of temperature. H. Gilman and Roy McCracken[36] (The yield of some Grignard Reagents) have shown that the average yield of R Mg X obtained from n-butyl bromide and magnesium is 91.23%.

The following amount of benzaldehyde used (in order to maintain the proportion 3 : 2) was calculated upon the basis of obtaining a 90% yield of the R Mg X compound:

Proportions and Amounts of Reagents Used

3 Moles	N Propyl Bromide	368.97 gms. (in 1100 cc. of ether)
3 Moles	Magnesium ribbon	72.96 "
	Ether	1000.0 cc.
	Benzaldehyde	265.08 gms. (in 500 cc. of ether)

The magnesium ribbon was thoroughly cleaned by using emery and filter paper. The ribbon (cut about 1 cm. in length) was placed in a dry clean five liter balloon flask. A small crystal of iodine was also added. The flask was closed with a three holed stopper carrying a mercury sealed stirrer, a dropping funnel and a reflux condenser to which was attached a calcium chloride tube containing calcium chloride and soda lime to exclude CO_2 and moisture+. Great care was observed in using anhydrous reagents. The ether used had just previously been distilled from sodium on to sodium. In order to start the reaction only 500 cc. of the ether was poured onto the magnesium through the reflux condenser. The mechanical stirrer was set in motion and the 368.9 g. of n-propyl bromide dissolved in 1100 cc. of ether, was slowly added through the dropping funnel. After about 100cc. of the propylbromide solution had been added a vigorous action occurred. The reacting mixture was cooled with running water to a slight visible reaction and the remainder of the ether (500 cc.) was added to the magnesium ribbon. The n-propyl bromide ether solution was then added slowly through the dropping funnel with constant stirring at room temperature

+ See Gilman and Meyers in their study of optimum condition for preparation of R Mg X compounds(37).

over a period of 2 3/4 hours*. After the propyl bromide solution had been added only traces of magnesium remained in the flask. The mixture was cooled with ice water and the benzaldehyde (previously dried over $CaCl_2$ and freshly distilled) dissolved in 500 cc. of ether was slowly added through the dropping funnel over a period of two hours. When most of the benzaldehyde had been added a whitish semi-crystaline mass appeared.

After standing twenty-one hours, it was poured onto finely crushed ice and shaken. An emulsion of a whitish oil appeared. The mixture stood for an additional 8 1/2 hours. It was then further decomposed by cold dilute HCl in order to facilitate extraction. The ether was distilled off and the remaining portion was subjected to fractional distillation. The third fractionation yielded:

88° - 92° at 6 mm pressure (most 90°-92°)	37.0 gms.
92° - 96° at 6 mm pressure (most 94°-96°)	293.6 "
above 96° at 6 mm pressure	1.0 "

The yield of the 92°-96° portion gives 78.2% of the theoretical (based upon the amount of benzaldehyde used). The specific gravity of a portion boiling between 94°-96° at 6 mm. pressure was determined as 0.978 at 18°/4°.

A second preparation of the carbinol gave a very excellent yield. The same technique was employed as in the first preparation, with the exception that the benzaldehyde (freshly distilled) was not dried over $CaCl_2$ and that the

* See H. Gilman and Meyers, J.Am.Chem.Soc. 45:159(1923. They find larger yields of R Mg X compounds are obtained by large quantities of anhydrous ether and slow addition at room temperature.

mixture was allowed to stand twelve hours instead of eight and one half hours just prior to being decomposed with cold dilute HCl. The following are the amounts that were used:

Proportions and Amounts of Reagents Used

1 mole	N-Propyl Bromide	204.4 gms (in 610 cc. of ether)
1 "	Magnesium Ribbon	40.4 "
	Ether	560.0 cc.
	Benzaldehyde	146.8 gms. (in 400 cc. of ether)

The above yielded upon fourth fractional distillation:

88°-92° at 6 mm. pressure	9.9 gms.
92o-94o " " " "	6.8 "
94o-96o " " " "	168.9 "

The yield obtained in this preparation (94°-96o fraction) gives 81.2% of theoretical. It gave a specific gravity of 0.974 at 18°/4°. A portion of the carbinol (94°-96°) was put into a freezing mixture. In a short time it solidified to a mass of white crystals, which melted at 14.5o. This agrees with the melting point of the carbinol prepared by Fritz Straus and Hans Grindel(38) who give M.P. 14.5o and B.P. at 19 mm. pressure 114°-115°.

August Klages(39) reports the boiling point of propylphenylcarbinol as 110° under 15 mm. pressure. He gives the specific gravity of the carbinol as 1.0213 at 18°/4 and its chloride as 0.9134 at 18o/4°. It appears that the specific

gravities reported by Klages should be just the reverse. The phenylpropylcarbinol reported by Grignard[40] is b_{10} 113°-115°; d_0 = 0.997; d 4/13.7 = 0.9861. This is in fair agreement with the density which I have found, i.e., 0.974 at 18°/4°. I also had occasion to prepare the chloride of propylphenylcarbinol and found the specific gravity to be 1.0182 at 18°/4°.

If one compares the boiling points reported by different investigators there seems to be some discrepancy. Etablissements Poulenc Fieres Fr 532, 464 Chem. Abs. 18:989 (1924) gives the boiling point of the carbinol at 119° under 12 mm. pressure. M. Puyal and M. Montague[41] report propylphenylcarbinol 115°-117° under 12 mm. pressure.

The first preparation of propylphenylcarbinol appears to have been made in 1891 by T. R. Marshall and W. H. Perkin[48]. They prepared the carbinol by the reduction of benzoyltrimethylene.

$$C_6H_5COCH\begin{cases}CH_2\\ |\\ CH_2\end{cases} + 2H_2 = C_6H_5\overset{H}{C}(OH)CH_2.CH_2.CH_3$$

They found that the carbinol distilled between 168°-170° under 100 mm. pressure and identified it by a combustion analysis.

2. Condensation of Propylphenylcarbinol With Phenol by Means of Aluminum Chloride.

Four condensations were made:

First Condensation:-

In the first condensation the following proportions and amounts of reagents were used:

1 Mole	Phenylpropylcarbinol	60.0 gms.
1 "	Phenol	37.6 "
.5 "	Aluminum chloride (anhy.)	26.7 "
	Anhydrous Petrolic ether	1000.0 cc.

The carbinol and phenol were dissolved in 1000 cc. of anhydrous petrolic ether (dried over $CaCl_2$) and placed in a jar which was fitted with a mercury sealed mechanical stirring apparatus. The jar was fitted with a four holed stopper, carrying a mercury sealed stirrer, reflux condenser, thermometer, and a tube for introducing aluminum chloride. The glass tube was tightly stoppered when not in use. A calcium chloride tube was used to exclude moisture.

The mixture was stirred vigorously and the aluminum chloride was added in small portions over a period of one hour. Upon the first addition of aluminum chloride a milky color appeared which later turned to a brick red color. Inside of half an hour a pale reddish gummy substance began to deposit on the walls of the jar and thermometer. HCl gas was quite noticeable. The temperature gradually rose from 20° to 28° then slowly declined. The mixture was stirred for one half hour longer, allowed to stand 1 3/4 hours and then stirred for 2 3/4 hours. After standing over night (10 hours) the reddish granular substance was

extracted with ether.

The ether was distilled off and the remaining portion subjected to distillation under diminished pressure. The first distillation yielded the following:*

up to 102° (atmospheric pressure)	discarded	
85° - 125° at 6 mm. pressure	6.3	gms.
125° - 175° " " " "	39.8	"
175° - 250° " " " "	6.8	"
above 250° " " " "	18.5	"

Second Condensation:-

The second condensation was carried out practically the same as the first, with the exception that only 400 cc. of petrolic ether was used. The time of addition of the aluminum chloride was 2 1/4 hours. The reaction appeared to proceed the same as in the first condensation. Care was not taken to use anhydrous ether or exclude moisture. The second condensation yielded the following on first distillation:

up to 105° (atmospheric)	discarded	
85° - 125° at 6 mm pressure	18.9	gms.
125° - 170° " " " "	37.6	"
170° - 220° " " " "	28.1	"
above 220° " " " "	10.9	"

* A portion of the ether extract was overlooked and was added to the second condensation.

Third Condensation:-

Proportions and Amounts of Reagents Used.

1 Mole	Propylphenylcarbinol	60.0 gms.
1.1 Moles	Phenol	41.3 "
.56 Moles	Aluminum Chloride	30.0 "
(Anhydrous)	Petrolic ether	450 cc.

The aluminum chloride was added over a period of 2 3/4 hours, keeping the temperature below 25o. After standing for five days the residue was decomposed with ice water and extracted with ether. Its first distillation yielded:

up to 105o (atmospheric)	discarded	
85o - 125o at 6 mm. pressure		15.0 gms.
125o - 170o " " " "		31.3 "
170o - 220o " " " "		26.1 "
above 220o at 6 mm. pressure		17.5 "

The three above condensations were combined and distilled as follows. The three 85o - 125o at 6 mm. fractions were combined and distilled at atmospheric pressure which yielded the following:

up to 175o atmospheric	4.7 gms.
175o to 190o atmospheric (mostly phenol)	27.5 gms.
above 190o atmospheric	5.4 "

The remaining fractions were distilled under diminished pressure and after many fractional distillations (about 15) the following fractions were obtained:-

Final Distillation of the Three Condensations+

91° - 143°	at 6 mm pressure		2.4 gms.
143° - 144 1/2°	" " "		14.2 "
145° - 150°	" " "		6.2 "
154° - 155°	" " "		49.9 "
165° - 180°	" " "		4.5 "
180° - 210°	" " "		7.4 "
210° - 213°	" " "	(most 211°)	18.0 "
213° - 216°	" " "		23.6 "
216° - 220°	" " "		1.7 "
220° - 223°	" " "		8.5 "
225° - 245°	" " "		10.1 "

The 49.9 gms. boiling 154° - 156° at 6 mm. pressure, after standing overnight in the ice box solidified to a paraffin like consistency. It should be stated here that upon the third fractional distillation (prior to the above final distillation) there was fourteen grams boiling 170° - 175° at 6 mm. pressure which also solidified to a paraffin like consistency.

Portions of this fourteen grams were dissolved in a number of different solvents to find a suitable medium; from which the compound could be purified by crystallization. One gram was recovered as a solid, the rest being used and a portion lost.

+ Note - The higher fractions from 180° to 245° were only fractionally distilled about eight times.

An attempt was made to purify the above 49.9 gms. (154°-156° at 6 mm.) in a similar manner. It was dissolved in petrolic ether and allowed to crystallize in the ice box. The compound crystallizes in long, very fine silky threads which soon takes on the appearance of a wad of absorbent cotton. Upon pressing out the petrolic ether between filter papers and allowing the remainder of the ether to evaporate in the ice box, a white compressed chalk-like mass is obtained. By following the above procedure, 5 grams of this chalk-like substance was obtained. The oily residue (filtrate) after allowing the petrolic ether to evaporate off in the ice box, solidified to a jelly like, sticky mass.

The purified compound melted 49° - 50°. Two combustions were made which gave the following results:

#1 substance .2397 grams; CO_2 .7150 grams; H_2O .1637 grams

#2 " .2254 " CO_2 .6995 " H_2O .1600 "

Calculated for $C_{18}H_{18}O$	Found
H = 8.020%	#1 (H = 7.974 % (C = 84.893 %
C = 84.906%	#2 (H = 7.943 % (C = 84.637 %

Fourth Condensation:-

A fourth condensation was run in which the following amounts were used:

62.5 gms	Propylphenylcarbinol
37.0 "	Phenol
35.0 "	$AlCl_3$ (anhydrous)
400 cc.	Petrolic ether (anhydrous)

The $AlCl_3$ was added over a period of two hours and twenty minutes, keeping the temperature below 25° by using cold water. Anhydrous petrolic ether (dried over $CaCl_2$) was used and the apparatus was made moisture tight. The product first took on a violet bluish color then gradually darkened. The product did not appear to be as red as heretofore, also seemed more gummy. It was stirred for two hours. After standing for two hours it was again stirred for two hours and allowed to stand twenty-four hours. The gummy mass became semi-crystalline. It was decomposed with ice, extracted with ether and dried over anhydrous K_2CO_3.

The first distillation yielded the following:

85° - 125° at 6 mm. pressure	11.2 gms.
125° - 160° " " " "	14.1 "
160° - 170° " " " "	17.3 "
170° - 180° " " " "	9.1 "
180° - 200° " " " "	5.2 "
200° - 250°	23.6 "

After fractional distillation (7 times) there was obtained: 19.0 gms. boiling at 153° - 156° at 6 mm. pressure.

The 19.0 gms. were put into a flask and allowed to solidify to its characteristic paraffin like consistency. Eighty cc. of Claisen's alcoholic potash solution (Annal. 442 : 224) was added. After long continued shaking (without heating) the solidified mass went into solution. It was shaken with petrolic ether (300 cc.) using 60 cc. portions.

The remainder was acidified with HCl (1 : 1) and extracted with diethyl ether. Both extracts were dried over K_2CO_3. The petrolic ether extract yielded four or five drops of a heavy oily non crystallizable residue.

The diethyl ether extract gave 17.8 gms. boiling at 154° - 156° (6 mm. pressure) which when put into the ice box solidified in its characteristic manner.

It was thought that by following the above method of procedure the compound could be freed from impurities which would facilitate crystallization. However, no difference was observed as it only solidified to its paraffin like consistency. The purified compound weighed 17.8 gms., which is 18.9% of the theoretical yield. This is in accordance with the observation that the longer the paraffin chain the greater the retarding effect(33).

3. Preparation of Ortho Hydroxy 1-1, Diphenylbutane.

The evidence offered heretofore that para alkylation of phenols resulted when aromatic alcohols and phenols were condensed, lies chiefly in the fact that their methyl ethers when oxidized with potassium dichromate and sulfuric acid gave paramethoxybenzophenone. Koenigs and Carl[43] used this method in determining the configuration of their methylphenylcarbinol prepared from styrole and phenol. This method, however, is a continued application from the investigation conducted by Rennie.

In 1882 Rennie[44] began a series of articles trying to establish the fact that the benzyl phenol prepared by Paterno[45] was a para derivative. He did a remarkable piece of investigation in which he endeavored to show (by analagous nitro brom substitution products) that the benzyl group must be present in the benzene ring para to the OH group. Rennie[46] was the first to show that when the methylether of benzyl phenol was oxidized it yielded para methoxybenzophenone, thus giving additional evidence as to the position of the benzyl group.

Fischer[47] maintains that in his condensations of aromatic alcohols and aromatic bases, that the relative position of the basic group to the combining carbon is always the same, i.e., 1 : 4. It is also a well established fact that the substituents already present in the benzene ring influence the position taken by the entering group. Holleman[48] in his investigations concludes that the following substituents, al-

ready present in the benzene ring directs the entering group to the para or ortho position in accordance with the following velocities.

$$OH > NH_2 > I > Br > Cl > CH_3$$

It is thusseen that the OH group passes the strongest influence to direct the entering group to the para or ortho position. However, in order to determine the characteristic difference between the ortho and para isomers, the ortho compound was prepared using Claisen's method of "Ringalkylation of Phenols"(49). He shows that ortho alkylation of phenols result when sodium phenolate is heated with certain alkyl halides in a non-dissociating medium. The employment of this method of comparison will furnish evidence as to which isomer is obtained in the aluminum chloride condensation and also whether or not both isomers may be obtained.

A Chlorination of Propylphenylcarbinol*

Eighty grams of the carbinol (94°-96° at 6 mm) were mixed with one and a half times its volume ofdry ether. Dry HCl was passed through for six hours at a temperature of 0°. It was then poured onto finely crushed ice, washed three times with cold water, extracted with ether and dried over anhydrous Na_2SO_4. The ether was distilled off and the remaining portion was fractionally distilled. After three

* References to chlorination of carbinols may be found in the bibliography(50).

distillations it yielded the following:

68° - 73° at 6 mm pressure	2.4 gms.
73° - 75° " " " "	79.0 "
above 75° at 6 mm pressure	3.1 "

The yield obtained was 89.3% of theoretical. It is a clear colorless liquid possessing a mild odor, resembling somewhat freshly graded orange peel. The specific gravity was determined and found to be 1.0182 at 18°/4°.

Amounts and Procedure Used In Claisen's Condensation

10.7	gms.	of	Sodium
48.3	"	"	Phenol
78.5	"	"	α-Chloro propylbenzene
125.0	"	"	Toluene

The finely chipped sodium was suspended in the toluene and the phenol was added. After a few minutes a vigorous action took place which gradually diminished in intensity. The mixture was heated on the water bath for two hours after which no sodium could be seen in the flask. The mixture was cooled and the chlorinated carbinol was added. No reaction was apparent. It was heated on a water bath for an hour (150° - 160° thermometer in oil) after which it stood over night. It was heated for 20 additional hours at 150 - 160° (with the exception that the temperature rose to 200° a couple of times). The mixture was cooled, washed twice with water

(to free from sodium chloride) and heated to 120° to distill off the water and toluene. The residue was dissolved in 250 cc. of Claisen's alcoholic potash solution (Ann. 442 : 224) and shaken out with 200 cc. of petrolic ether using 50 cc. portions.

The remainder was acidified with HCl (1 + 1) and 125 cc. of water was added to dissolve the sodium chloride. It was cooled and extracted three times with diethyl ether.

The above petrolic ether extract after four fractional distillations gave the following:

8.3 gms.	boiling at	60°-61° at	6 1/2 mm pressure
16.6 "	" "	123°-125° "	6 mm. pressure
11.8 "	" above	200° "	" " "

B. Identification of Phenylbutylene

The 8.3 gms. portion boiling (60-61° at 6 1/2 mm.) was identified as normal phenylbutylene(51). Its boiling point was found to be 186° - 188° (atmospheric). The specific gravity was found to be 0.9051 at 18°/4°. Its dibromide formed in chloroform solution with the calculated amount of bromine gave long slender needles which melted 70°-71°.

It seems reasonable to expect that some phenylbutylene might be obtained since Radziszewski(51) obtained his phenylbutylene by the action of bromine on boiling phenylbutane and then distilling at atmospheric pressure. Also P. Genvresse(52) found that alpha-chloro propylbenzene could be converted into the unsaturated allylbenzene by boiling with KOH.

C. Isolation of 1 - Phenylbutylphenylether

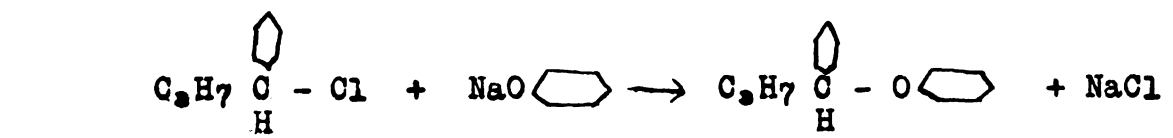
The 16.6 gm. portion boiling 123°-125° at 6 mm. pressure was a light mobile colorless liquid with a very faint geranium like odor. Its specific gravity was found to be 1.0067 at 25°/4°.

It was identified by two combustions which yielded the following:

#1 Substance .2663 gms.; CO_2 .8278 gms.; H_2O .1906 gms.
#2 " .2480 " CO_2 .7708 " H_2O .1765 "

Calculated for $C_{16}H_{18}O$	Found
	#1 (H = 8.009%
	(C = 84.771%
H = 8.020%	
C = 84.906%	#2 (H = 7.963%
	(C = 84.765%

According to Claisen[49] it is to be expected that some ether is formed together with the ortho alkylation product. The formation of the ether probably occurs according to the following equation:



D. Isolation of Ortho-Hydroxy 1, 1 Diphenylbutane

The diethyl ether extract of the acidified alcoholic potash solution (page 25) yielded upon four fractional distillations the following:

10.4	gms.	boiling	at	75°-125°	at	6	mm	pressure (mostly phenol)
20.8	"	"	"	144°-146°	"	"	"	"
7.0	"	"	"	146°-200°	"	"	"	"
4.7	"	"	above	200°	"	"	"	"

The 20.8 gm. portion boiling at 144°-146° (6 mm. pressure) was a light straw colored viscous oil, which would not crystallize when placed into a freezing mixture or allowed to stand in the ice box for many weeks.

Two combustions were made which gave the following results:

#1 Substance .2535 gms.; CO_2 .7865 gms.; H_2O .1818 gms.

#2 " .2521 " CO_2 .7829 " H_2O .1817 "

Calculated for $C_{16}H_{18}O$	Found
H = 8.020%	#1 (H = 8.025%
C = 84.906%	(C = 84.615%
	#2 (H = 8.065%
	(C = 84.695%

4. Preparation of Para Hydroxy 1-1, Diphenyl-butane Employing Friedel and Crafts Reaction.

One condensation was run in which Friedel and Crafts reaction was used, in order to determine if this method could be successfully employed in obtaining para hydroxy 1-1, diphenylbutane. Friedel and Crafts reported finding such reactions as usually impossible(8). Also by comparing Huston and Friedeman's reaction with Friedel and Crafts reaction, it affords a method of determining the relative influence maintained by the hydroxyl and chloride groups in such reactions.

Amounts of Reagents Used

1 Mole	α-Chloro propylbenzene	60.0gms.
1 "	Phenol	33.47 "
.5 "	Aluminum Chloride	23.7 "
	Petrolic ether (anhydrous)	500 cc.

The same apparatus was used in this condensation as was used in the preceding condensations. Anhydrous materials were used and the apparatus was fitted with a calcium chloride tube to exclude moisture. The aluminum chloride was added in small portions over a period of 2 3/4 hours. This rate of addition allowed the temperature to rise from 20° to 25° (no external cooling). After about 2/3 of the aluminum chloride had been added the temperature began slowly to fall. In this condensation when 2 to 3 grams of the aluminum chloride had been added a gummy mass appeared in the bottom of the jar. It continually increased and toward the end of the run became

semi-granular. When all of the aluminum chloride had been added it was stirred for 1 3/4 hours. It was allowed to stand 1 1/2 hours and then stirred for an additional 3 1/4 hours. After standing over night (14 1/2 hours) it was decomposed with ice water and dilute HCl. It was then extracted with ether and dried over anhydrous K_2CO_3. After heating to 100° it was fractionally distilled under diminished pressure.

First Distillation

80° - 110°	at 6 mm. pressure	8.7 grams
110° - 200°	" " " " (most 180°-200°)	51.5 "
200° - 235°	" " " "	14.1 "

After six fractionations of the last two fractions (above) the following was obtained:

Final Distillation

80° - 110°	at 6 mm. pressure	8.7 gms.
145° - 154°	" " " "	4.0 "
154° - 156°	" " " "	21.1 "
165° - 167°	" " " "	6.6 "
170° - 180°	" " " "	6.7 "
180° - 200°	" " " "	2.8 "
200° - 235°	" " " "	19.7 "

A Identification of P-Hydroxy 1-1, Diphenylbutane

The fraction boiling 154°-156° at 6 mm. pressure, when left in the ice box over night (without seeding) solidified in the manner characteristic of para hydroxy 1-1, diphenylbutane. It was further identified by the melting point of its benzoyl derivative (70°-71°).

From this preliminary investigation it would appear that there is no great difference between the activity of the hydroxyl and chloride groups under the above conditions.

Perhaps it should be pointed out that there was no fraction obtained between 110° to 145° (6 mm. pressure) as was found in the preceding condensations. No high boiling fraction above 235° at 6 mm. pressure was obtained.

5. Esterification and Bromination of the Ortho an Para isomers.

The benzoyl derivatives were prepared by the Schotten-Baumann method of esterification. This serves as a means of identifying the phenolic hydroxyl group. One gram of the purified para hydroxy 1-1, diphenylbutane; obtained from the propylphenylcarbinol and phenol condensations, was dissolved in the calculated amount of KOH, using just sufficient water to cause solution. The calculated amount of benzoyl chloride was added. It was kept cool and after shaking well for 1/2 hour it became semi crystalline. After allowing to stand over night and washing with water to free from impurities, it was crystallized from alcohol. The long retangular crystals after purifying, melted at 70°-71°.

The oily residue (filtrate portion) which solidified to a jelly like sticky mass (page 17) gave a benzoyl derivative melting 70o - 71°. This fact indicates that most of the 49.9 gms. boiling 154° - 156o (6 mm. pressure) is para hydroxy 1-1, diphenylbutane. Crystallization is apparently hindered by slight impurities.

The benzoyl derivative prepared from the condensation product obtained by Friedel and Crafts method (21.1 gms. boiling 154o - 156° at 6 mm. pressure) gave long rectangular crystals melting 70o-71o. Thus furnishing additional proof that the products obtained in the two methods of synthesis are identical.

The benzoyl derivative of the ortho compound (obtained by Claisen's condensation) failed to crystallize from alcohol or dried petrolic ether but remained as a sticky, gummy mass, in which very few crystals appeared. No further investigation of this compound was made at this time.

The fraction obtained from the three combined carbinol and phenol condensations 14.2 gms. boiling at 143-144 1/2° (at 6 mm. pressure) after purifying by Claisen's alcoholic potash, gave 11.5 gms. boiling 143o-147o at 6 mm. pressure. Since this fraction corresponds closely to the boiling point of the ortho compound (Claisen's condensation) its benzoyl derivative was prepared. The product obtained consisted of a sticky, gummy mass, which from all appearances seemed to be identical with that obtained when the ortho compound was used. Thus there is an indication that there is a small amount of the

ortho compound formed in the carbinol and phenol condensation.

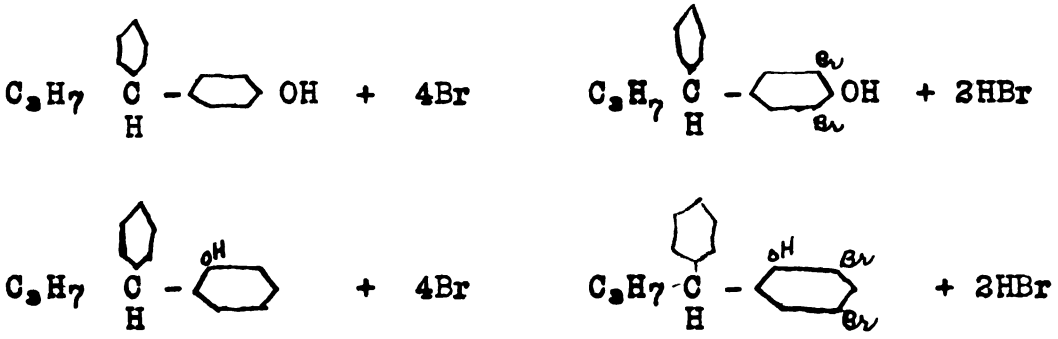
In order to furnish additional evidence three brom derivatives were prepared. The following products were brominated:

#1. Nine grams of the ortho hydroxy 1-1, diphenylbutane obtained from Claisen's method of condensation.

#2. Nine grams of the product boiling 143o-147° (at 6 mm. pressure) obtained in the three carbinol and phenol condensations.

#3. Twelve grams of the para hydroxy 1-1, diphenylbutane obtained from the three carbinol and phenol condensations. The 13 gms. used, was the filtrate portion that solidified to a jelly like sticky mass when allowed to remain in the ice box.

Each product was dissolved in chloroform. The amount of bromine added was calculated according to the probable reactions.



Ebullition of HBr was quite noticeable. The brominated products were allowed to stand for several days after which the ether was distilled off. The products did not crystallize. The boiling points are as follows:

#1 (above)

Entire product boiled 184-185° at 6 mm. pressure.

#2.

7.5 gms.	184° - 185° at 6 mm. pressure.
1.5 "	185° - 186 1/2° " " "

#3

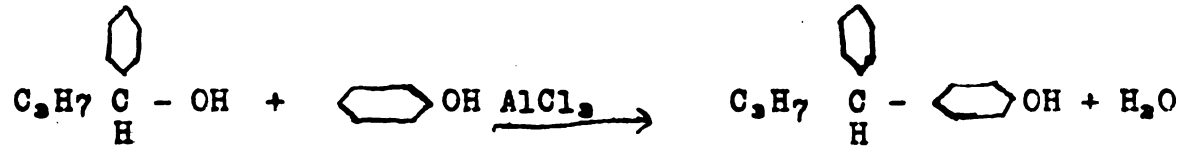
2.5 gms.	187° - 188° at 6 mm. pressure
9.5 "	188° - 189° " " " "

From the above facts (esterification and bromination) it is very evident that both isomers are obtained in the aluminum chloride condensation.

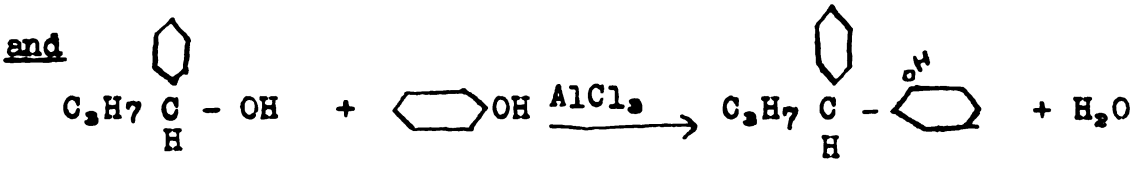
SUMMARY

1. Prcpylphenylcarbinol can be prepared in excellent yield by the Grignard Reaction if heat is not applied and by controlling the relative amounts of reagents used.

2. Propylphenylcarbinol will condense with phenol in the presence of aluminum chloride to give para-hydroxy 1-1, diphenylbutane together with a small amount of the ortho isomer.

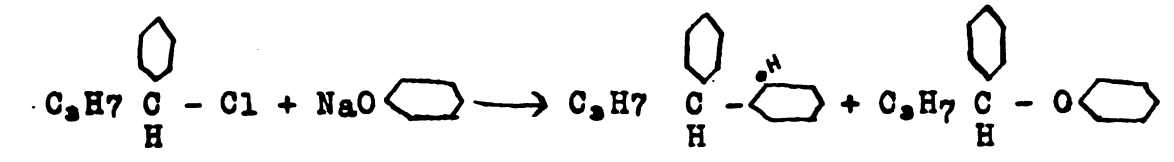


and



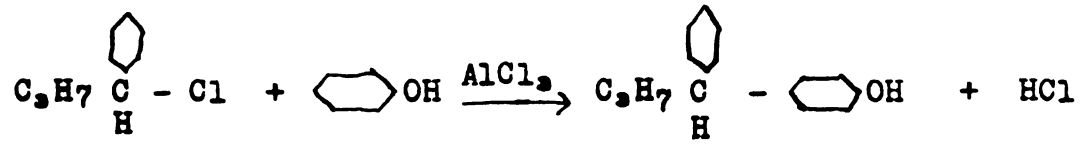
3. The yield of the above para compound (18.9% of theory) substantiates the fact previously found, that the longer the paraffin chain, the greater its retarding effect in such condensations.

4. α-chlorobutylbenzene will react with sodium phenolate to give ortho hydroxy 1-1, diphenylbutane and phenylbutylphenylether.



There is also formed a small amount of phenylbutylene under the described conditions.

5. It was found that the phenolic hydroxyl group does not interfere with the preparation of para hydroxy 1-1, diphenylbutane when Friedel and Crafts method is applied under the described conditions.



6. By comparing Huston and Friedeman's Reaction with Friedel and Crafts Reaction the relative influence of the carbinol hydroxyl and chloride groups are found to be approximately the same.

7. The isomers readily yield to bromination and the para compound gives a crystalline benzoyl derivative.

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