A study of St. von Kostaneckis synthesis of alpha naphthoflavone
by Wendell Iver Wall

A THESIS Submitted in partial fulfillment of the requirements for the Degree of Master of Science in Chemistry
Montana State University

Abstract:
1. Alpha-naphtholflavone was not successfully prepared by the writer in studying Kostanecki's synthesis.

2. The various steps along the synthesis were studied with special emphasis on products of 2-benzalacetonaphthol preparation. More work on the final steps is necessary.

3. Several possible tautomers of intermediate products were isolated.

4. One definite example of a possible molecular rearrangement is cited.

5. A method for obtaining more uniform results and better yields was found for the 3-aceto-1-naphthol preparation.

6. It was shown that color did not correlate with the various melting points in the case of 2-aceto-1-naphthol as pointed out by Witt and Braun.

7. In future runs of 2-benzalacetonaphthol it seems more desirable to use less than the calculated amount of sodium hydroxide and heat reaction longer.

8. This study opened up many new, interesting and unsolved problems for future investigation.

A STUDY OF ST. VON KOSTANECKI'S SYNTHESIS OF ALPHA NAPHTHOFLAVONE.

BY

WENDELL I. WALL.

A THESIS

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A STUDY OF ST. VON KOSTANECKI'S SYNTHESIS OF ALPHA NAPHTHOFLAVONE.

INTRODUCTION:

The purpose of this investigation, which is stated in the title, obtained its stimulus, originally, from the economic factor, demand. Alpha-naphthoflavone was perhaps first prepared by Kostanecki in his studies of the flavone groups.[4] It has, like other numerous examples of laboratory curiosities, developed through occasional isolated and sporadic researches to be a desirable laboratory and commercial reagent.[1,3] In recent years there have been attempts to prepare alpha-naphthoflavone by the Eastman Kodak Company in order to meet trade demands, but, as far as is known, all endeavors have been unsuccessful.[7]

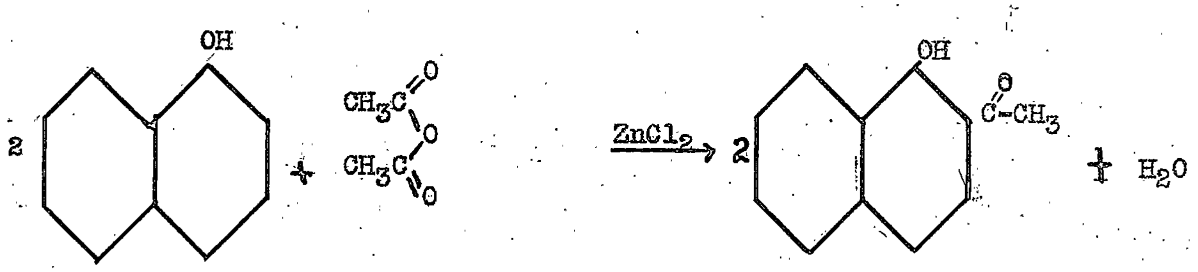
Alpha-naphthoflavone has been shown to be useful as an indicator in water purification control where chlorine is used as a sterilizing agent.[1] A relationship exists between the oxidizing ability of a given sample of water and the necessary amount of chlorine for destruction of the bacteria present. By titrating chlorinated water with alpha-naphthoflavone as an indicator, the point where an excess of chlorine is present can easily be detected, and thus a sufficiency maintained. Naphthoflavone has also been shown to be more sensitive to the presence of iodine (1:1,000,000) than starch.[1]

The method investigated in this research was that of Kostanecki's. This method was also briefly tried for commercial production by Dr. O. E. Sheppard while with the Eastman Kodak Company, and it resulted in a failure. The literature cites also others who have tried the method and have been unsuccessful in the case of beta-naphthoflavone. However, the method has been duplicated by Pfeiffer and Grimmer successfully.[5] Other methods of synthesizing alpha-naphthoflavone are also found in the literature but were not investigated by the writer.[8] Kostanecki's method, although somewhat cumbersome, seemed more orthodox and logical than those of other investigators.

It was the aim of the writer to work out step by step the synthesis and to isolate the desired end products in pure form. Laboratory conditions were varied in every case, such as temperature, time, procedure and concentration of reagents. The success of each step was based upon correlation in every case with the intermediate products obtained by Kostanecki; the ultimate aim being good yields, correct melting point, color and crystalline form. In practically all the steps the reactions appeared to be very labile and even slight variations of conditions affected considerably the products obtained. For this reason many products of side reactions were isolated in the pure state. In many cases one was led to believe that tautomers were obtained instead of the products sought for. Although the ideal condition would have been to definitely establish the identity of the various compounds, the vast amount of time and work required to do this forced the writer to abandon this situation. In some cases, however, ultimate analysis of the compounds were attempted but definite identity was not established. The phenomena of intramolecular rearrangement of one compound was very evident in one case. A more detailed discussion of the results of this work will be given in the experimental part of this paper. A modification of the method of preparing 2-aceto-1 naphthol, whereby one can get better yields and a more pure product was worked out. A more detailed description of this will also be given in the experimental part of this paper. The presence of tautomers in the case of 2 aceto-1-naphthol has been postulated by Witt and Braun[9] in their study of the acetonaphthols. This same grouping was present throughout the remainder of the intermediate products so one would naturally postulate that tautomers existed in the other intermediates.

2-ACETO-1-NAPHTHOL.

Method: The method used in preparing 2-aceto-1-naphthol was that outlined by Witt and Braun.[9] The procedure is briefly as follows: Dissolve 60 g. of alpha-naphthol in 30 cc. of acetic acid and 45 g. of acetic anhydride; to this mixture add 30 g. of zinc chloride. Heat the mixture for 30 minutes on an oil bath at a temperature of 140°C. in a 500 cc. round bottom flask, connected with a reflex condenser. Then pour into the mixture about 300 cc. or more of hot water and stir until a red oily layer separates out at the bottom of the flask; if the red layer does not separate at the bottom, not enough hot water has been added. Separate the red oily layer off and it will, through slow cooling, congeal into a crystalline paste. It is then leached with several portions of alcohol until the red coloring matter is removed. The remaining light grey crystals are recrystallized from alcohol, thereby producing aceto naphthol in apple green crystals, melting at 101-103°C.



Discussion of Experimental Work on 2-Aceto-1-Naphthol: The first difficulty encountered in this step was the inconsistency of the yields. It was found that if one heated the preparation too long, too much of the red oily impurities were produced. If one heated the mixture above the boiling point of acetic anhydride (140° C.), there was a tendency to produce the di-aceto naphthol and large quantities of the red oily liquid impurity. (See Table 1) It was found that on adding an excess of acetic anhydride and heating it for about an hour at 140°C., one could produce almost entirely the 2,4 diaceto naphthol melting at 140°C. The conditions of the procedure were worked out so that the writer found he could obtain good yields of aceto naphthol consistently and that the product was much lighter in color, and better appearing one than those obtained by the original method. The color of the crystals after recrystallization varied from light yellow to apple green and the melting point varied from 97 to 101; the lighter colored product usually exhibiting the lower melting point. Gattermann, in working with acetonaphthos, claimed that the ortho acetonaphthol was apple green in color and melted at 101-103.[2] He also postulated that the light yellow colored compound, of melting point of 98-99°C. was the para isomer. This was, however, disputed by Witt and Braun, who found that on further recrystallization and purification from alcohol of the ortho compound, one obtained the lower melting point derivative of the lighter color. That the melting point dropped instead of rising with increase in purity was explained by the fact that there were two tautomers of 2-aceto-1-naphthol; one form being almost colorless and having a low melting point, and the other, the green colored form, with a melting point of 101-103°C. Various gradations of color and melting points between these two extremes were solid solution mixtures of the two forms. Witt and Braun claim to have prepared a para compound with a melting point of 198°C.

After making several attempts to prepare 2-Benzal-aceto-1-naphthol, which resulted in obtaining consistently good yields of a yellow product, not having the properties of the benzal derivative, it was thought desirable to investigate the 2-aceto-1-naphthol. The probability that the yellow compound obtained by the writer was the tautomer of the 2-Benzal acetonaphthol, seemed likely. The approach made by the writer was to take different shades of ortho-acetonaphthol and boil in alcohol with decolorizing carbon, filter and recrystallize several times. There was found to be no definite correlation between color and melting point. Of the nine different shades and color fractions produced, it was established that a pale straw yellow compound had the highest melting point of 98-100°C., while the lowest had a pale green color, melting at 96.5-98°C. The colors in most cases were pale green to yellow and pale yellow. There was a general overlapping of melting points and color. The decolorizing carbon removed considerable green color from the acetonophthols in all cases. The results are tabulated in Table II. It is established, therefore, that the green color is an impurity of the acetonaphthol and that the pure product is pale yellow, melting at 97-99°C. However, the writer, in working with the alcoholic extractions of the red oily impurities of 2-aceto-1-naphthol, believes that the green color is closely associated with the red oil impurities and that a tautomer of the yellow is a purple colored compound. This possibility will be discussed later in this part of the paper.

In the new method to be outlined for the satisfactory preparation of 2-aceto-1-naphthol, all modifications of the general procedure have been found by experiment to materially aid in obtaining good yields and uniform products.

TABLE I.

RUNS OF 2-ACETO-1-NAPHTHOL.

No.	Grams of a-naphthol used	Per cent yield	Heating time for reaction mixture Hrs.	 Min.	 Temp.	M. P. product	Color
1.	36	43		30	140	98-101	Apple green
2.	60	-	1		140	139.5-140*	White
3.	60	-		30	140	139.5-140*!!	"
4.	30	5	4	water	bath	94-95	Apple green
5.	30	63	1		135	95-98	" "
6.	30	3		10	140	98-99	" "
7.	60	88	1	30	135	96-100	" "
8.	60	32	1	30	125	98-101	" "
9.	20	12	24	water	bath	98-100	" "
				30	130		
10.	20	19	2		135	98-100	" "
11.	215	60	2		125	99-100	" "
				10	135		"
12.	250	70	3	30	125	98-100**	" "
13.	190	50	1		135	98-100**	" "
14.	400	73	2		130	98-100**	" "
				30	135		
15.	200	75	3		128	98-100**	" "
				10	140		
16.	60	83	12	water	bath	98-99.5**	" "
			2		125		" "
				10	140		
17.	200	75-80	Same as (16)				" "
18.	200	70-80	"	"	"		" "

* This product was the 2,4-Diaceto-1-naphthol.

** The reaction mixture was mechanically stirred while adding the acetic anhydride.

!! 15 grams in excess of acetic anhydride was used.

TABLE II.

PURIFICATION RUNS ON 2-ACETO-1-NAPHTHOL.

No.*	Times recrystallized from decolorizing carbon	Color of product	Melting point
1.	1	Pale green	96.5-98
2.	2	Pale yellow	96.7-98.2
3.	2	Light apple green	97.8-99
4.	1	Pale green yellow	97.5-99.8
5.	2	Yellow	98.0-100
6.	1	Same as (3)	97.3-98
7.	1	" " "	98.0-99
8.	1	" " (4)	97.5-99
9.	1	" " "	97.5-98

* All runs are samples from runs 12, 13 and 14 of Table I.

Modified Method for Preparation of 2-Aceto-1-Naphthol: The same proportion of ingredients is used as in the original procedure, except that one-third more acetic acid is desirable. Dissolve the alpha-naphthol and the freshly fused and pulverized $ZnCl_2$ in the acetic acid by heating on a water bath. All of the $ZnCl_2$ will not dissolve. Then place the mixture on a mechanical stirrer allowing the acetic anhydride to drop in slowly from a separatory funnel. The acetic anhydride should be added rapidly enough so that the heat of the reaction maintains the temperature of the solution in the flask from 70-85°C. Stirring should be continued for one-half hour after all the acetic anhydride has been added. Connect the flask to a reflex condenser and heat on a water bath for 10-15 hours. Transfer to an oil bath and heat from 1 to 2 hours at 125°C., after which the temperature is gradually raised to 135-140°C. (uncorrected) for about five to 10 minutes. Remove the oil bath and condenser from flask and allow to cool slightly. To the solution add boiling water with stirring or shaking until a red oily layer separates at the bottom of the flask. The red oil is separated from the water with a separatory funnel and placed in a beaker to cool. The substance congeals to a crystalline paste. The paste or crystals are broken up and placed into about 150cc. of cold alcohol, stirred and filtered. The crystals are then washed with several small portions of cold alcohol. After most of the red impurities have been washed off the product is recrystallized from alcohol. Yellowish green needle-like crystals of 2-aceto-1-naphthol are obtained, melting at 98-100°C. The yield is 50 to 60 grams, which is approximately 70 per cent of the theoretical yield.

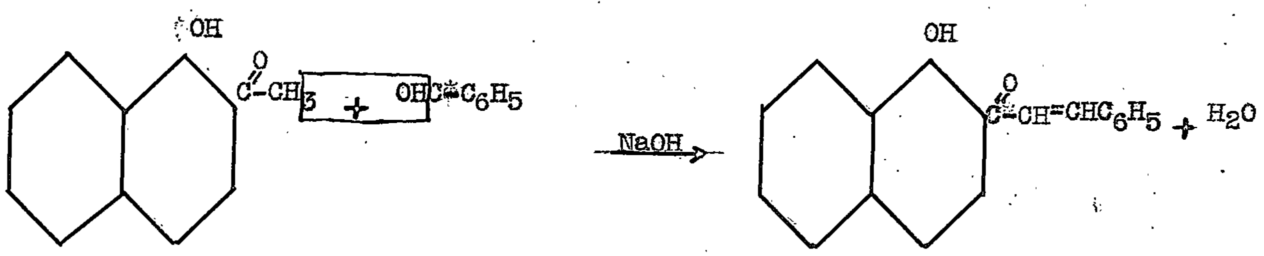
Alcohol Extractions of Red Impurities Formed from Aceto Naphthol Preparations: After considerable quantities of the alcohol extractions of the 2-aceto-1-naphthol preparation had been collected, it was thought desirable to distill off the alcohol and acetic ester formed. After distillation and a water bath, there remained a thick oily liquid which would not solidify on cooling. The mass was placed in water made slightly acid with acetic acid and boiled for several hours. The water was decanted off of the black mass at the bottom and more water was added and boiled. The water washings were cooled to about 10°C. and a flaky crystalline mass precipitated out. The crystals were pale rose colored plates. There were considerable quantities of the material obtained but no work was done in an attempt to identify it. Throughout this paper the pale rose colored compound will be referred to as (A). The black mass not soluble in the hot water, solidified on cooling. The mass was bottled and allowed to stand several months. It was then noticed to have pale green needle-like crystals sublimed around the black mass. The crystals were undoubtedly 2-aceto-1-naphthol. The substance was then dissolved in hot alcohol and it went into solution giving a beautiful dark reddish purple color. On cooling black crystals were obtained. This black colored compound shall be referred to hereafter in this paper as (B). The crystals were homogenious in appearance and gave a melting point of 100-101°C. On diluting the mother liquor, more of a dark purple crystalline material precipitated. The melting point was 100.5-100.8°C. From general appearance and melting points they are probably the same compound. Compound B was allowed to stand for a couple of months uncovered, on a tray in a locker. On examining the substance again numerous needle crystals of a pale green color were present mixed with the black. It is estimated that at least twenty-five per cent of the mixture was pale green crystals. This would indicate possibly the material is a mixture of the two tautomers of 2-aceto-1-naphthol. The melting point of B and the 2-aceto-1-naphthol are identical. That the substances were tautomeric forms of each other was not definitely established and more research along this line is necessary.

2-BENZAL-ACETO-1-NAPHTHOL.

Method: In 100 grams of alcohol dissolve 10 grams of 2-aceto-1-naphthol. To the mixture add 6 grams of benzal dehyde and stir mechanically. After all the ingredients are dissolved add very slowly 20 grams of a 50 per cent NaOH solution. The solution gradually turns a light orange to red color. In a flask connected with a reflux condenser the material is heated for 1 hour on a water bath. Too long heating according to Kostanecki was undesirable. After the end of the reaction, the clear red liquid is poured in about 400-600 cc. of cold water which is being mechanically stirred. A dark red gummy precipitate is formed which is filtered off. To the filtrate add cautiously acetic or hydrochloric acid until the solution is still alkaline but just about neutral. This can be determined by the color of the filtrate which is a light orange in comparison to the acid or neutral condition which is decidedly yellow with the rapid formation of a precipitate. In the slightly alkaline condition there is sometimes a formation of an orange precipitate. Mechanical stirring greatly facilitates coagulation of the precipitate. The precipitate is filtered and dissolved in hot alcohol. By careful fractional crystallization, cooling gradually and diluting with water, dark orange crystals were obtained which give a melting point on recrystallization of 126.5°-127°C. The yields are very small. A light orange fraction is also obtained which on recrystallization from alcohol comes out in plates which melt at 76°-78°C. Brown crystalline impurities were also separated from this fractionation.

The slightly alkaline filtrate from which the orange precipitate had been filtered is acidified with acetic or hydrochloric acid. There is formed large quantities of a yellow precipitate which is let stand for a few minutes and given an occasional shaking. The precipitate flocculates, rising to the top, and is filtered off. The precipitate is recrystallized from alcohol or acetic acid. The crystals being bright yellow plates melt at 95.5°-96°C. Some of this yellow material is also obtained in the final dilution of the alcohol filtrates in the purification of the above orange precipitate.

The orange crystals with a melting point of 126.5°-127°C. shall be known in this paper as compound (C), the light orange crystals with a melting point of 76°-78°C. as compound (D) and the yellow crystals melting at 95.5°-96°C. as compound (E). Kostanecki states that 2-benzalaceto-1-naphthol crystallizes in orange colored leaves and has a melting point of 125-126°C. This method is original to the author except the reaction quantities which are Kostanecki's.



<u>Discussion of Experiment on 2-Benzaleceto-1-Naphthol</u>: In attempting to prepare 2-benzalacetonaphthol, much difficulty was presented when the yields of the 2-benzolacetonaphthol (C) were negligible and large yields of an unidentified yellow compound (E) were obtained. Several attempts were made and a variety of conditions experimented with (Table III), but only in a few instances were any yields of Kostanecki's benzal compound isolated. In almost every attempt, on the first dilution of the preparation with cold water, one obtained a red sticky mass which was soluble in alcohol and acetic acid. Attempts to recrystallize the material from either alcohol or acetic acid and fractional recrystallization by dilution of the solvent with water yielded small amounts of a brown powder which melted at 122-128°C. This may be some 2-benzalacetonaphthol, but the yields were so small, and the product so difficult to purify that attempts to obtain the compound from this source were abandoned. It is very difficult to interpret the results of the various runs because of the many undeterminable factors affecting the reactions. Many times the results could not be duplicated in subsequent trials.

<u>Time of Reaction</u>: The effect of varying the time of heating the reaction was studied. In run (1) of Table III the mixture was refluxed for three hours and allowed to stand until cool. This was the only time that any appreciable amounts of 2-benzalacetonaphthol was obtained. There was considerably less than the stipulated amount of NaOH used. This may have been a factor aiding the reaction. In a later run (2) the reaction was refluxed for 6 to 8 hours. None of compound C was isolated on purification. There was a small yield of the gummy red benzaldehyde polymer, and a good yield of compound E.

Two runs were made to determine the effect of not heating the reaction the specified hour. In run (3) the time was one-half hour. There was no yield of C but there was a considerable yield of D and E. In run (4) the time was fifty minutes. There was no benzaldehyde polymer formed. Good yields of compound E and some D were obtained.

Concentration: An attempt was made to determine the effect of decreasing the concentration of sodium hydroxide. The effect of run (1) is mentioned in discussion of the reaction time. In run (4) slightly over three-fifths of the amount of NaOH was used. There was a formation of less of the gummy red benzaldehyde polymer. An excellent yield of E was obtained. In run (5) the same concentration as (4) was used. No polymer was formed. Dilution of the reaction mixture with water obtained an orange precipitate which gave some of compound C on fractional recrystallization. A good yield of E was obtained. In run (6) slightly over three-fourths of NaOH was used. There was some reddish orange precipitate formed on dilution which yielded a small quantity of C and D. Not as good a yield of E was obtained. In run (7) about half of the required alkali was added. On acidifying reaction mixture and dilution, an orange precipitate formed which on recrystallization gave compound D.

A run (8) was made in which the one-half quantity of alkali was added to the reaction mixture which had been previously warmed. The product was a dark brown precipitate with no compound E formed. The warming of the alkali produced very undesirable results.

It was observed that in the precipitation of compound E from the reaction mixture, that sometimes the precipitate would turn a yellowish brown on standing before it could be filtered. If the compound is first recrystallized from glacial acetic acid and then from alcohol, a very pure product is obtained.

TABLE III.

RUNS OF 2-BENZALACETO-1-NAPHTHOL.

No.	Grams of aceto-naphthol used	Grams of 50% NaOH used	Reaction heating time (hours)	Yield of grams in (C)	(D)	(E)
1.	100	150	3	18	-	90
2.	30	55	6-8			25
3.	35	300	0.5	-	12	20
4.	100	130	0.8	trace	-	68
5.	100	130	1	4	-	95
6.	20	33	1	2	8	10
7.	10	12	1	-	8	-
8.	10	10	1	black gummy mass		
9.	50	100	0.8		6	52
10.	100	400	1			73
11.	10	100	1	3		5
12.	18	120	1	2		7
13.	15	140	2.5		8	5
14.	40	80	1	trace	trace	22
15.	20	40	1	2		14.5
16.	20	20	1	4		12

<u>Investigation of Compound E</u>: Because of the continual fine yields of the yellow compound under almost all experimental conditions the writer thought it advisable to further investigate the compound. The compound went into sulfuric acid solution with a reddish yellow color, a property similar to that of 2-benzalacetonaphthol.

Perhaps the most striking phenomena in regard to the compound was its undergoing a change of melting point on standing. A quantity of the substance had been prepared and purified for the purpose of making an ultimate analysis. The compound on successive recrystallizations from alcohol exhibited a constant melting point of 95.5-96°C. The quantity that was not used was bottled and set aside over the summer months. When work was resumed the following fall, the compound was again recrystallized and found to have a melting point of

125.5-127°C. This shows evidence of some possible molecular rearrangement.

In an attempt to have some more of the compound undergo the same change, several samples of different preparations with melting points of 95-96°C were placed in sample bottles and exposed to daylight by placing in an unshaded spot out of doors. After several months, a melting point was again taken, and it was found not to have changed in either of the samples. It was thought that possibly warm temperatures might effect the change, so the samples were placed in a warm room near a water boiler. After a month the melting points of the samples were still unchanged. A sample of the compound was placed in alcohol and reflused for several days with still no change of melting point. All efforts to duplicate the change in melting point were unsuccessful.

The writer believes, however, that the compound did undergo such a change. Proof could not be established, because of not being able to attain or determine conditions favorable for the change. If the compound did undergo that change, it must definitely be a tautomer of compound C, because the melting point after the change is identical with that of compound C.

Several combustions of the compound were made.

Analysis

No.	%H_2	%C	%O_2
1	7.304	75.64	17.05
2	5.114	76.19	18.69
3	5.59	77.10	17.31
4	7.13	76.35	16.51
5	5.97	48.15)	KOH
6	5.41	87.6)	solution
7	5.63	42.22)	became
8	5.63	)	exhausted
Ave.	5.63	76.77	17.6

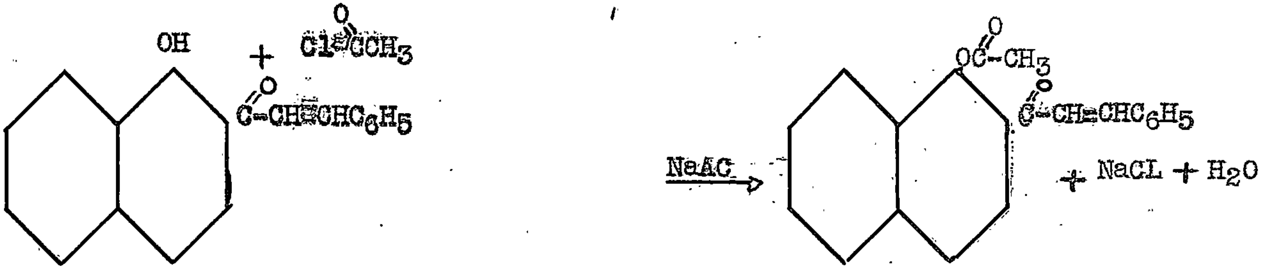
Calculated formula: $C_{18}H_{14}O_3$.

Assigned fomula: 2-benzalacetonaphthol: $C_{18}H_{14}O_2$.

Further work on this compound is necessary to definitely establish its identity. The writer was unable to postulate any structure of the compound from the calculated emperical formula and the condition of its formation.

ACETYL-2-BENZALACETO-1-NAPHTHOL

<u>Method</u>: Place 10 grams of 2-benzalaceto naphthol in a flask containing 40 to 50 grams of acetyl chloride. Connect to a reflux condenser and add 5 grams of freshly fused sodium acetate. Reflux on a water bath from 4 to 6 hours. After reaction has taken place, cool the solution down below room temperature and add water drop by drop through the condenser tube until all the excess acetyl chloride is destroyed. Then add 50 to 100 cc. of water in excess, shake and filter. Recrystallize from dilute alcohol. The acetyl derivative according to Kostanecki crystallizes in yellow plates from dilute alcohol, having a melting point of 95-96°C. This is the author's own method.



<u>Discussion of Experiment on Acetyl-2-Benzalaceto-1-Naphthol</u>: Much detailed work on this step of the synthesis could not be done, due to the lack of 2-benzalacetonaphthol with which to work. In only a few cases were the acetylation products purified. The reason for this was; first, that the mixtures of compounds prepared were very difficult to isolate even by fractional recrystallization and second, that the starting material usually used was compound E. An attempt to get naphthoflovane from this compound was made without any attention given to the intermediate products.

In the case where the compound C was used the intermediates were isolated in each case and also in two runs with compound E. The runs of these compounds from the 2-benzalacetonaphthol through to the final product will be treated separately in this paper.

In run (1) of Table IV the acetyl compound formed on recrystallization gave yellow colored plates melting at 95-96°C. The compound had a slightly disagreeable odor and the crystalline structure was slightly different from the compound E which was acetylated. This was the only indication that there had been a chemical change. The only reason for doubt was that the original compound and the product both have the same melting point. There is a possibility that acetylation did not take place.

Several acetylations were run of compound E, but complete purification of the products was not affected before brominating the compound in the next step. On heating acetylation reaction for 10 to 14 hours, a mixture of light yellow crystals with large quantities of distinct large square plates of a darker yellow compound was obtained. Melting point of the product ranged from 90 to 96°C (impure).

In run (2) of compound C of product from run (5), Table III, a yellow crystalline substance was obtained which melts at 125-126°C.

In acetylation of both compounds C and E the products of both runs showed no appreciable change in melting points from that of the original compounds. The general appearance of the products did show some change as to color and crystalline structure. Whether acetylation definitely had taken place or not is still a matter to be settled.

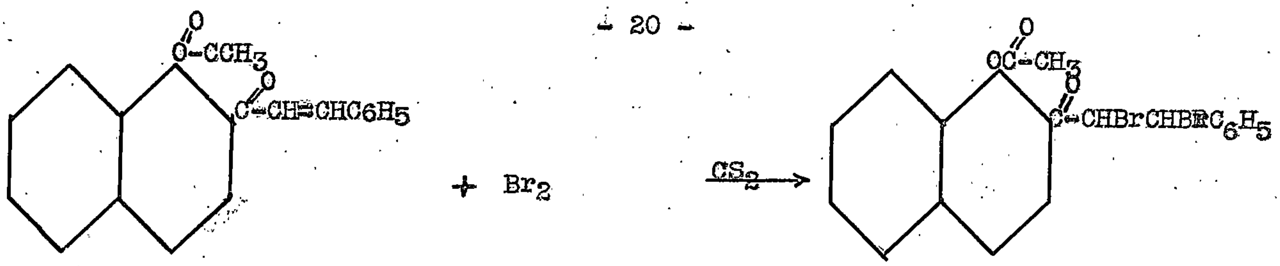
TABLE IV.

RUNS OF ACETYL-2-BENZALACETO-1-NAPHTHOL.

	Grams of material used			Reaction heating time	Characteristics of Products		
No.	(C)	(D)	(E)	(hours)	Yield grams	Crystals-Color	M. P.
1.			10	12	8	Yellow plates	95-96
2.	4			0.5	1	" needles	125-126
3.			22	6	15	" plates	97-99
4.			68	15	not det'n	Mixture	
5.			68	4	" "	"	
6.		23		12	" "	"	90-91.5
7.			15	12	" "	"	95-96
8.			20	10	" "	Dark yellow plates	78-85
9.			10	10	" "	Mixture	108-110
C-1	18			8	28	Deep yellow	125.5-127
E-1			34	8	40	Yellow plates	95-96

ACETYL-2-BENZALACETO-1-NAPHTHOLDIBROMIDE

Method: To 10 grams of acetyl-2-benzalacetonaphthol dissolved in 300 grams of carbon disulfide is added an equimolecular proportion of bromine (3 per cent solution in carbon disulfide) very slowly with mechanical stirring. No hydrogen bromide should be evolved. After allowing considerable time for the reaction to take place, the carbon disulfide is distilled off on a water bath until about 50 cc. of reaction mixture in carbon disulfide remain in the flask. This is then washed into a beaker and the carbon disulfide is allowed to evaporate off. The product, according to Kostanecki, on recrystallization from benzine is white needles melting at 186-187°C. This method incorporates a few variations of Kostanecki's method which is not clearly outlined in literature, and is the method used by the author.

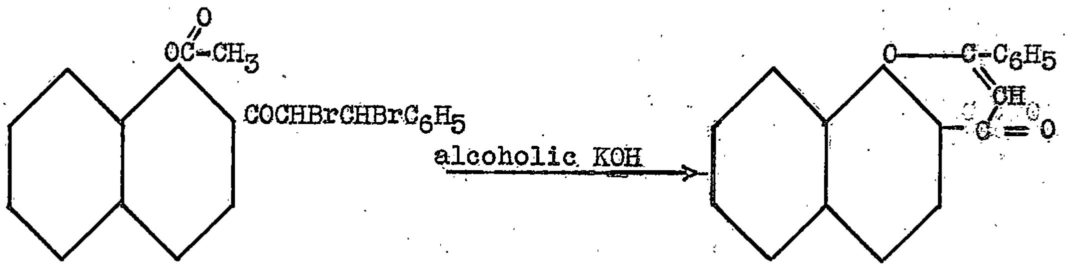


Discussion of Experimental Work on Acetyl-2-Benzalaceto-1-Naphtholdibromide: In attempts to brominate impure mixtures of the acetylation product of compound E, much hydrogen bromide was given off. Cooling of the reaction in ice water bath and great dilutions of the reaction products in carbon disulfide did not aid the situation to any great degree. The products were very soluble in benzene and carbon disulfide. On recrystallization several times from alcohol, a pale yellow substance melting from 125-127°C. was obtained. No white colored crystals were obtained in this step to agree with the dibromide of Kostanecki's. Purification of the products of all the bromination runs before attempting the final step of the synthesis was omitted. Table V shows runs of bromination experiments.

ALPHA-NAPHTHOFLAVONE

Method: Suspend 10 grams of the dibromide of acetyl-2-benzalacetonaphthol in 100 cc. of alcohol. Stir mechanically and add in proportion three moles of potassium hydroxide in a 30 per cent water solution. The dibromide goes into solution with a reddish yellow color. After reaction has taken place, which may be facilitated by warming slightly on a water bath, water is added to the solution and the alpha-naphthoflavone precipitates out. It is filtered and recrystallized from alcohol. According to Kostanecki, beautiful pale yellow leaflets should be obtained melting at 154-155°C. The method, as outlined, is original with the author.

Attempt to prepare:



Discussion of Experimental Work on Alpha-Naphtholflavone: Hit and miss methods were tried in almost every case in an attempt to obtain the naphthoflavone. The products of the bromination were treated with alcoholic potassium hydroxide and stirred until solution took place. A reddish yellow colored solution was obtained at all times in the alcohol. It was thought desirable to reflux the reaction for mixture a few minutes before diluting with water to obtain the product. Acidifying the filtrate also brings down more of the product if any excess alkali is used.

Aside from the two runs on compound C and E, only one other run gave anything that was of interest. A pale yellow substance was formed after strong heating with the alcoholic potassium hydroxide, which on recrystallization from alcohol, have a melting point of 125-126°C. The dibromide of the two runs also had the same properties. Qualitative tests for bromine before and after treating with alkali were made. The compound gave a positive test before and a negative test after. The melting points before and after were the same. The melting points were 127-128°C.

No alpha-naphthoflavone was obtained.

SPECIAL RUNS OF COMPOUNDS C AND E

Special runs of compounds C and E obtained in the 2-benzalacetonaphthol preparation were made through the final steps. The intermediate products were purified by recrystallization in each step for the sake of comparing the two runs. A resume of the runs is given below.

Run C-1: (Product of run (1), Table III.)

1. Acetylation.
Dark yellow plates from alcohol; M.P. 93-96°C., (Kostaneckis' M.P. 95-96°C.)

2. Bromination. HBr given off.
Yellow needles from alcohol. M.P. 125-127°C., (Kostaneckis' M.P. 186-187°C.) Positive bromine test.

3. Alcoholic KOH.
Boiled with alcohol and decolorizing carbon. Pale green crystals, M.P. 127.5-128°C., (Kostaneckis' M.P. 154-156°C.). Dissolved in concentrated sulfuric acid with an orange yellow color. Is soluble in hot alcohol, acetone, benzene. Negative qualitative test for bromine.

Analysis

No.	%H_2	%C	%O_2	
1.	4.157	58.31	37.533	(Wall)
2.	3.252	49.92	46.828	"
3.	2.920	51.36	45.72	(Dajani)
4.	3.032	47.63	49.338	"
5.	2.529	45.58	51.89	"
6.	3.86	36.55	59.59	"

Due to the failure to get desirable checks in analysis on compound of run C-1, and lack of time to make further analyses, the author thought it undesirable to attempt to assign a formula to the product.

Run E-1: (Product of run (1), Table III.)

1. Acetylated.
Bright yellow leaves. M.P. 125.5-126°C., (Kostaneckis' M.P. 95-96°C.)

2. Bromination. No HBr given off.
Orange yellow crystals from acetone, insoluble in alcohol. M.P. 168-171°C., (Kostaneckis' M.P. 186-187°C.) Positive bromine test.

3. Alcoholic KOH.
Reflux for one-half hour. Orange crystals from benzene, using decolorizing carbon. M.P. 173-175°C., (Kostaneckis' M.P. 154-156°C.). Went into sulfuric acid with a deep red color. Soluble in hot acetone and benzene. Alpha-naphthoflavone gives a green fluorescence in concentrated sulfuric acid.

Analysis

No.	%H_2	%C	%O_2	
1.	7.436	57.57	Sample not dried	(Wall)
2.	2.872	64.65	32.48	"
3.	3.932	63.43	32.64	"

Calculated emperical formula of No. 2 and 3 - $C_{21}H_{14}O_8$. Assigned formula - $C_{19}H_{12}O_2$.

TABLE V.

BROMINATION AND ALCOHOLIC POTASSIUM HYDROXIDE TREATMENT.

			Product of alcoholic KOH treatment		
No.	Grams of acetyl der. used	HBr evolved	Yield	Color	M.P.
1.	10 from (E)	much	7	Yellow	115-119
2.	10 " "	"	5	Pale orange	125-126
3.	25 mixture from (E)	"	15	Mixture of brown and yellow crystals.	
4.	10 from (E)	"	4	Pale yellow	125-127
C-1	28	none	10	Orange yellow	174-175
E-1	40	slight	20	Pale green	127.5-128

SUMMARY

1. Alpha-naphtholflavone was not successfully prepared by the writer in studying Kostanecki's synthesis.

2. The various steps along the synthesis were studied with special emphasis on products of 2-benzalacetonaphthol preparation. More work on the final steps is necessary.

3. Several possible tautomers of intermediate products were isolated.

4. One definite example of a possible molecular rearrangement is cited.

5. A method for obtaining more uniform results and better yields was found for the 2-aceto-1-naphthol preparation.

6. It was shown that color did not correlate with the various melting points in the case of 2-aceto-1-naphthol as pointed out by Witt and Braun.

7. In future runs of 2-benzalacetonaphthol it seems more desirable to use less than the calculated amount of sodium hydroxide and heat reaction longer.

8. This study opened up many new, interesting and unsolved problems for future investigation.

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