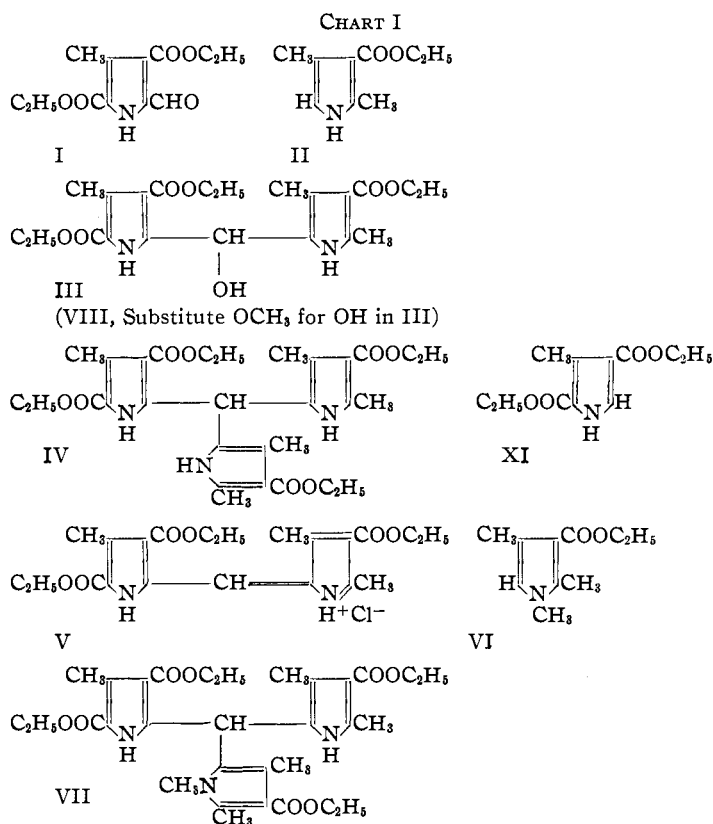
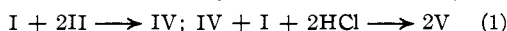


[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF THE JOHNS HOPKINS UNIVERSITY]

Studies in the Pyrrole Series. IV. A Dipyrrolymethene which is a True Intermediate in its own Formation¹

BY JOSEPH H. PADEN,² ALSOPH H. CORWIN AND WILLIAM A. BAILEY, JR.³

In the preceding communication^{4a} it was demonstrated that a stepwise synthesis of 3,5,4'-tricarboxy-4,3',5'-trimethyldipyrrolymethene hydrochloride (compound V, Chart I) could be achieved in which a tripyrrolymethane (compound IV) was an intermediate if two moles of the alpha-free pyrrole II were used to one mole of the pyrrolyl aldehyde I and the resulting tripyrrolymethane cleaved subsequently by the addition of another mole of aldehyde as in scheme (1):



The data then current did not permit a decision as to the course of the reaction when equimolar quantities of the pyrrole II and the aldehyde I were used. As an alternative to the tri-

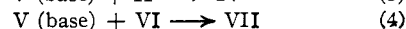
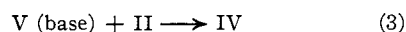
pyrrolymethane mechanism given in scheme (1), direct formation of methene from carbinol may be formulated:



The present paper summarizes a group of experiments on the relative velocities of the reactions concerned which permits a decision between these possibilities.

In previous communications on the mechanism of the aldehyde synthesis of dipyrrolymethenes, it has been assumed arbitrarily that dipyrrolycarbinols are intermediates in the various cleavages.^{4b,5} While it still seems necessary to retain the assumption of a carbinol as the first reaction product of aldehyde and alpha-free pyrrole, it is now unnecessary to assume any chemical intermediate between tripyrrolymethanes and dipyrrolymethenes, either in cleavage or in recombination, since it can be demonstrated that the methenes themselves are capable of combining with alpha-free pyrroles to form tripyrrolymethanes. This new condensation bears a superficial resemblance to the Diels-Alder reaction. In certain cases the tendency to reaction is so strong that the free base of the methene condenses spontaneously with the alpha-free pyrrole; in other cases it is necessary to use acid catalysts such as potassium acid sulfate or hydrogen chloride or to use the hydrochloride of the methene as one of the reagents. With the aid of this reaction it is possible to make the direct measurements of velocity necessary to an understanding of the course of the methene synthesis.

By the application of this new condensation, direct confirmation of our conclusion^{4b} with respect to the hindering influence of an N-methyl group upon condensation is now available and is obtained by a comparison of the following two reactions:



(1) Presented at the Milwaukee meeting of the American Chemical Society, September, 1938.

(2) Present address: American Cyanamid Co., Stamford, Conn.

(3) Present address: Shell Development Corp., Emeryville, Calif.

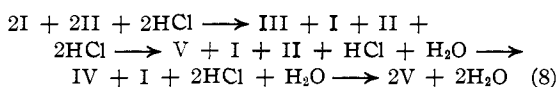
(4) (a) Corwin and Andrews, THIS JOURNAL, 59, 1974 (1937);

(b) 59, 1975 (1937); (c) 59, 1979 (1937); (d) 59, 1976 (1937);

(5) Corwin and Andrews, *ibid.*, 59, 1987 (1936).

added catalyst; reaction g proceeds only when potassium acid sulfate is added; reaction f proceeds only when hydrogen chloride is added. It must be pointed out, however, that the addition of hydrogen chloride stabilizes the forward direction of reaction f by its mass action effect, so these relationships are not uncomplicated velocity relationships.

The most convincing confirmation that the relative velocities in the presence of hydrogen chloride, the standard reaction conditions for methene formation, are the same as those in the presence of potassium acid sulfate is obtained by the following experiment: as the solution of aldehyde I and pyrrole II used for the synthesis of methene V in the presence of hydrogen chloride becomes increasingly dilute the time of initial appearance of a precipitate of the methene is progressively delayed, as is the time required for obtaining the maximum yield. Under these conditions it is possible to stop the reaction well before the appearance of methene and to isolate the chemical intermediates in the reaction. When equimolar quantities of aldehyde and pyrrole are used, the intermediates isolated are equivalent quantities of unreacted aldehyde I and tripyrrylmethane IV. *This demonstrates that the tripyrrylmethane is an intermediate in the formation of the methene hydrochloride.* Since the methene hydrochloride is an intermediate in the formation of tripyrrylmethane from carbinol, which is the most probable primary product of the condensation of aldehyde and pyrrole, it follows that *the methene hydrochloride is an intermediate in its own formation.* These relationships are summarized in scheme (8).



A number of "stable" tripyrrylmethanes of the type of methane IV have been prepared.⁸ Their apparent stability would have constituted a strong argument against the adoption of a condensation to tripyrrylmethanes as a general scheme for the synthesis of methenes from aldehydes. This objection has now been removed by the proof that the case which appears to be the most unfavorable to the tripyrrylmethane mechanism is one in which the demonstration of the reality of this mechanism is relatively simple. The reaction in which a satisfactory experimental

determination of mechanism will be most difficult is that in which cleavage of the tripyrrylmethane is rapid.

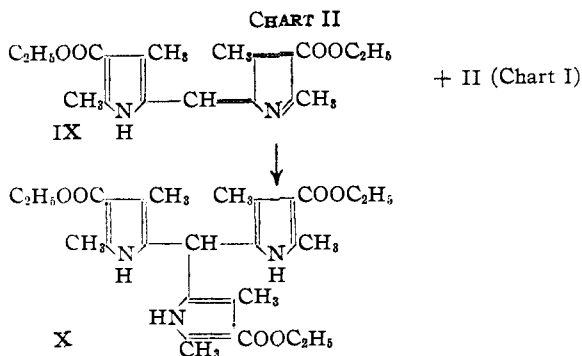
It is of interest to inquire into the mechanism of the last step of scheme (8). One possibility is that tripyrrylmethane IV and aldehyde I combine to form a compound which cleaves to give methene V. All our attempts to prepare such a compound have met with failure. A second possibility is that cleavage to give methene V does not take place until a molecule of aldehyde I and methane IV collide in a preferred orientation or with a sufficiently activated collision. This possibility might be explored by suitable kinetic measurements. There exists the further possibility that the reaction of formation of the tripyrrylmethane is reversible⁹ and that the formation of methene is due to the slow displacement of the process toward a more stable product. In the preceding paper^{4a} considerable evidence was presented to show that the reaction is actually reversible. For this reason we incline to the third scheme for the course of the cleavage. According to this scheme the rate determining step in the reaction is the combination of aldehyde I with pyrrole II. This slow step intervenes twice, the first time in the presence of excess pyrrole II which favors the reaction by its mass action effect, the second time in the presence of traces of the pyrrole, formed by cleavage of tripyrrylmethane IV. It is the slowness of this reaction combined with the rapidity of the recombination of pyrrole II with methene V which permits the isolation of tripyrrylmethane IV as an intermediate.

A corollary consistent with the preceding argument would be that the formation of readily cleavable tripyrrylmethanes from methenes and alpha-free pyrroles should be a slower process than the formation of "stable" tripyrrylmethanes. This argument already has been explored, scheme (5), for a case in which the methene remains constant and the pyrrole is varied and was found to be true in that case. The complementary case is now reported (Chart II).

Methene IX combines with pyrrole II in the presence of potassium acid sulfate to form tripyrrylmethane X. This reaction is slower in the

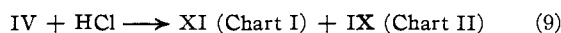
(9) The word *reversible* is used here in the usual sense of the organic chemist to signify a process proceeding in both directions. It does not imply that the process is energetically reversible in the thermodynamic sense. In fact, if one were to devise an electrode system to measure the free energy of such a reaction, the electrode behavior would undoubtedly be erratic and the physical chemist would say that he was dealing with an irreversible system.

(8) Fischer and Ernst, *Ann.*, **447**, 139 (1926).



presence of the catalyst than the reaction with the free base of methene V is without any catalyst. These observations are consistent with the assumption that the ready cleavage of tripyrrylmethane X is due essentially to the slowness of the reverse reaction of formation of the tripyrrylmethane. This assumption is also consistent with the course of the cleavages of N-methyl tripyrrylmethanes in which the effect of the N-methyl group has been shown to be due to hindrance of the condensation to tripyrrylmethane. Thus again we are led to regard the reactions involved in the formation of dipyrromethenes as a complex series of reversible reactions in which all possible cleavages and condensations take place. One is not justified in regarding these reactions as equilibria, however. The velocities of the competing reactions vary over a sufficiently wide range that products obtained after the usual reaction times allowed in organic work may not be the products thermodynamically most stable and, furthermore, the products obtained after a very short time may be different from those obtained in the normal time.

As a further illustration of the time dependence of these reactions, we may cite the cleavage of tripyrrylmethane IV in the presence of hydrogen chloride. A dry ether solution of this "stable" tripyrrylmethane becomes colored within a few hours after adding dry hydrogen chloride. The color deepens during the course of several weeks and crystals are slowly deposited upon the walls of the reaction vessel. These crystals were identified as the hydrochloride of methene IX, presumably resulting from the reaction shown in scheme (9).



The possibility of this reaction was discussed in our previous paper.^{4d} Unfortunately, it has not been possible to isolate pyrrole XI from the reaction. This experiment lends support to the view

that cleavage takes place at all bonds in tripyrrylmethane IV, the chief factor differentiating it from less stable tripyrrylmethanes being the rates of the reactions involved.

One of us, J. H. P., wishes to acknowledge his indebtedness to the Chemical Foundation for a post-doctoral stipend which made this investigation possible. The authors also wish to acknowledge the courtesy of the Carbide and Carbon Chemicals Corporation in furnishing the acetoacetic ester used in this work.

Experimental Part

Condensations of 3,5,4'-Tricarboethoxy-4,3',5'-trimethyl-dipyrrylmethene (Methene V Base) with 2,4-Dimethyl-3-carboethoxy-pyrrole (Pyrrole II).—Four-tenths gram (0.001 mole) of the free base of methene V was dissolved in 20 cc. of pure dioxane, dried over 40% sodium amalgam and freshly distilled from sodium; 0.184 g. (0.0011 mole) of pyrrole II was dissolved in 5 cc. of dioxane, purified identically. The solution of pyrrole II was poured into the methene solution, which was shaken quickly. The empty flask was rinsed with 5 cc. of dioxane. The reaction flask was shaken for fifty seconds after the addition of the main portion of the pyrrole and was then poured into 200 cc. of ice and water. A colorless precipitate was formed with no evidence of methene. The product was filtered off, washed well with water and dried by suction in the dark. It was then dissolved in 15 cc. of 95% ethanol and diluted with water until the oil would come out immediately upon removing the flask from the hot-plate. A tiny crystal was added as a seed, and induced crystallization immediately; yield, 0.54 g. (95%) of tripyrrylmethane III, m. p. 190.5–191.5°.

The distillation of the dioxane is important. The methene color remains unchanged for at least fifteen minutes in dioxane decanted from sodium amalgam. The reaction was made to go with an experiment similar to that above except that the dioxane was decanted from sodium amalgam and 0.01 g. of powdered potassium bisulfate was added; yield, 98% of a material melting at 190–192°. A similar experiment was performed using distilled dioxane and potassium bisulfate. Fifteen seconds after mixing, the contents of the flask were poured into 200 cc. of ice and water containing 0.5 g. of sodium carbonate. The tripyrrylmethane was isolated and purified as described above; yield, 94%, m. p. 190–192°. The reaction follows a similar course in redistilled absolute ether: 0.4 g. of the methene was dissolved in 75 cc. of absolute ether, distilled from sodium into the flask. The alpha-free pyrrole was dissolved in 25 cc. of absolute ether, distilled into another flask. The solutions were protected from air by soda lime tubes. Upon mixing, the methene color faded to a light yellow within twenty seconds and this yellow color had disappeared within forty seconds more. The ether was distilled off on a steam-bath and the residue recrystallized as described above; yield, 0.540 g. (95%); m. p. 191–192°. Thus a single recrystallization gave a very pure product which also showed less tendency to darken in the air than most others.

Condensations of 3,5,4'-Tricarbethoxy-4,3',5'-trimethyldipyrromethene (Methene V Base) with 1,2,4-Trimethyl-3-carbethoxy-pyrrole (Pyrrole VI).—Four-tenths of a gram (0.001 mole) of the free base of methene V and 0.199 g. (0.0011 mole) of the pyrrole VI were dissolved in 40 cc. of absolute dioxane, freshly distilled from sodium, and 0.01 g. of potassium bisulfate was added. The color faded to a light yellow and the mixture was poured into ice and water after three and one-half minutes. The product was a pale yellow solid with no evidence of unreacted methene. The suspension was seeded with a tiny crystal and allowed to stand overnight in the icebox before filtering. For the isolation of tripyrromethane VII, the following procedure was used. After filtering it was dried in air, warmed with 10 cc. of hexane, cooled and filtered; yield, 0.530 g. or 91%. This crude product melts at 151–153°. The m. p. may be raised by recrystallization from dilute methanol to 155–156°. A similar experiment was performed but the mixture was poured into ice and water after one minute. The original methene was isolated as described in the first experiment; yield, 40%.

A reaction mixture not containing potassium bisulfate was allowed to stand for one hundred minutes. There was no apparent change in color and no tripyrromethane could be isolated. A similar experiment was then allowed to stand for over two hours in direct sunlight and then overnight in the laboratory. There was no appreciable change in color in this time.

Preparation of 3,5,4'-Tricarbethoxy-4,3',5'-trimethyldipyrromethene Hydrochloride (Methene V) from its Free Base and from its Carbinol-methyl-ether (Compound VIII).—Two-tenths gram (0.0005 mole) of chromatographically purified methene base V was dissolved in 75 cc. of absolute ether. The solution was cooled in an ice-bath and a stream of dry hydrogen chloride was passed in. As soon as the gas reached the solution a precipitate was formed. Hydrogen chloride was passed in for one minute and the flask was shaken for another minute. The product was filtered off rapidly; yield, of methene V, 96%. The experiment was repeated using an equivalent quantity (0.217 g.) of carbinol methyl ether VIII. This was dissolved in 50 cc. of ether and the methene precipitated without cooling; yield, 93%. In this experiment, as in the preceding, the precipitation of the methene salt was instantaneous.

Condensations of 3,5,4'-Tricarbethoxy-4,3',5'-trimethyldipyrromethene Hydrochloride (Methene V) with 2,4-Dimethyl-3-carbethoxypyrrole (Pyrrole II).—Four-tenths gram of the free base of methene V was dissolved in 75 cc. of absolute ether distilled from sodium; 50 cc. of similar ether was cooled in ice while a strong stream of dry hydrogen chloride was passed in for twenty minutes; 0.167 g. of pyrrole II was dissolved in this solution and then poured rapidly with shaking into the methene solution. A copious precipitate formed which all redissolved within five seconds. The flask was shaken for two minutes and then the contents were poured into 150 cc. of cold 5% sodium hydroxide in a separatory funnel. The ether solution was washed with a second 150-cc. portion of cold sodium hydroxide and with two 100-cc. portions of cold dilute sodium chloride. (The salt was added to facilitate separation of layers.) The ethereal layer was evaporated

and the residue recrystallized from dilute ethanol; yield of tripyrromethane IV, 0.52 g. or 91.5%, m. p. 191–192°.

The experiment above was repeated with the variation that the ethereal solution of hydrogen chloride was added to the methene free base before the addition of pyrrole II. A copious orange precipitate of the methene hydrochloride V separated immediately but practically all of it redissolved within ten seconds. After three minutes the pyrrole II was added in the solid state. After standing four minutes the solution was poured into sodium hydroxide and the tripyrromethane was isolated as described above; yield, 95% of a product melting at 187–188°.

The experiment may be performed with dry dioxane, using only 16 cc. as the solvent. The reaction is complete after fifteen seconds; yield of tripyrromethane IV after two recrystallizations from ethanol, 90%, m. p. 191–192°. When either dioxane or ether is used which is decanted from sodium or sodium amalgam, no reaction takes place until the addition of the hydrogen chloride. The yield in ethereal solution may be increased to 97.5% by bubbling in the hydrogen chloride for only five seconds and then evaporating the ether on the steam-bath.

Condensations of 3,5,4'-Tricarbethoxy-4,3',5'-trimethyldipyrromethene Hydrochloride (Methene V) with 1,2,4-Trimethyl-3-carbethoxypyrrole (Pyrrole VI).—Four-tenths gram of the free base of methene V was dissolved in 100 cc. of absolute ether; 0.181 g. of pyrrole VI was added to the solution. It dissolved rapidly. Hydrogen chloride gas was passed into the solution without cooling for two minutes. As soon as the gas reached the solution a precipitate formed but after the first fifteen seconds apparently no more was formed. The flask was shaken at room temperature for three minutes after the addition of the hydrogen chloride and the solution was filtered; 5 mg. of the methene salt V was obtained, corresponding to a recovery of 1.1%. The filtrate was shaken for five minutes more without the formation of more precipitate, showing that the methene salt was not formed from the tripyrromethane VII which was present in the solution. The tripyrromethane was then isolated in a manner similar to that used for the isolation of tripyrromethane IV from hydrogen chloride solution; yield, 0.51 g. or 88%; m. p. 150–152°. Recrystallization from dilute methanol raised the melting point one degree.

When it was desired to isolate the reaction product after a shorter time, the reagents were dissolved in part of the ether and the other part was saturated with hydrogen chloride and then added all at once. An orange-colored precipitate formed immediately. In a typical experiment, the flask was shaken for two minutes after the addition of the hydrogen chloride and then filtered rapidly; yield of methene salt V, 11%; yield of tripyrromethane VII, isolated as above, 72%; m. p. 150–152°.

In a similar experiment, carbinol methyl ether VIII was substituted for methene base V, and 40 cc. of hexane was used as solvent. The methene salt was filtered off after two minutes; yield, 73%. The filtrate was practically colorless. On drawing air over it for a few minutes a solid separated, which was allowed to stand overnight, filtered and dried; yield, 24% of tripyrromethane VII. It is thus evident that hexane is less well adapted to the production of tripyrromethane than is ether, probably

because of the insolubility of the methene salt in hexane. When the experiment was varied by adding only one bubble of hydrogen chloride to prevent the formation of a large amount of methene salt, only a small amount of methene salt precipitated out and it was accompanied by tripyrrylmethane.

Isolation of Intermediates from the Reaction of 2-Formyl-3,5-dicarbethoxy-4-methyl-pyrrole (Aldehyde I) and 2,4-Dimethyl-3-carbethoxy-pyrrole (Pyrrole II).—Five hundred and six milligrams (0.002 mole) of aldehyde I and 334 mg. (0.002 mole) of pyrrole II were dissolved in 20 cc. of absolute ether freshly distilled from sodium. The solution was cooled to 5° in an ice-bath and dry hydrogen chloride was passed in for three minutes. The solution, which was originally colorless, slowly deepened to a light tan. It was poured into 200 cc. of cold 5% sodium hydroxide solution. The flask was rinsed with 20 cc. of ether. The ether and sodium hydroxide solutions were carefully but vigorously shaken for thirty seconds. The ether solution was washed rapidly with two 100-cc. portions of cold 5% sodium hydroxide and finally with two 100-cc. portions of dilute sodium chloride. The sodium hydroxide and sodium chloride solutions were run into an excess of cold dilute hydrochloric acid solution, precipitating the unchanged aldehyde II. This was thoroughly cooled in ice, filtered, and the colorless solid dried in air; recovery, 0.225 g. or 44.5% of a product melting at 124–125° without recrystallization; mixed m. p. with pure aldehyde I (m. p. 127°), 126–127°. One crystallization from dilute ethanol raised the m. p. to 125–126°.

The ether was evaporated on a steam-bath, leaving a sticky yellow residue, partly crystalline. This was recrystallized from dilute ethanol; yield, 0.535 g. or 47% of a yellowish solid, m. p. 191–192°; mixed m. p. with pure tripyrrylmethane IV (m. p. 191–192°) 191–192°.

To duplicate as closely as possible our postulated mechanism for the methene reaction, the following experiment was performed: 434 mg. (0.001 mole) of carbinol ether VIII, 254 mg. (0.001 mole) of aldehyde I and 167 mg. (0.001 mole) of pyrrole II were dissolved in 100 cc. of absolute ether and the solution treated as in the preceding experiment; recovery of aldehyde I, 215 mg. or 85%; yield of tripyrrylmethane IV, 490 mg. or 86%.

Further Examination of the Course of the Condensation of Aldehyde I and Pyrrole II. (a) **In Concentrated Solution.**—Five grams of aldehyde I and 3.34 g. of pyrrole II were dissolved by warming in 350 cc. of anhydrous ether and then cooled in an ice-bath. A moderate stream of dry hydrogen chloride was passed in. The first precipitation of methene salt V took place after two minutes. The gas was passed in for fifteen minutes and the flask was allowed to stand in the ice-bath for twenty minutes more. The precipitate was filtered and washed with 50 cc. of hexane; yield, 6.8 g. or 78.5%. After standing in the icebox overnight, 0.1 g. additional methene salt was obtained; total yield, 79.8%.

(b) **In Dilute Solution.**—Two hundred fifty-three milligrams of aldehyde I (0.001 mole) and 167 mg. of pyrrole II (0.001 mole) were dissolved in 100 cc. of absolute ether and treated as in the foregoing experiment. No change in color was visible for four minutes and the first precipitation of methene salt took place after fourteen minutes.

The salt was filtered off after twenty-five minutes; yield, 0.270 g. or 61.5%. The filtrate was placed in the icebox for another hour and yielded 70 mg. or 16% additional methene salt. On standing another hour, 20 mg. or 4.5% additional methene salt was obtained. On further standing no more methene was obtained and the solution turned purple; total time, one hundred forty-five minutes; total yield, 82%.

(c) **With Potassium Bisulfate.**—One hundred twenty-seven milligrams (0.0005 mole) of aldehyde I and 167 mg. (0.001 mole) of pyrrole II were dissolved in 10 cc. of anhydrous dioxane and 0.01 g. of potassium bisulfate was added. The solution was allowed to stand in the dark with occasional shaking for an hour. It was then poured into 100 cc. of ice and water containing 0.5 g. of sodium carbonate and the tripyrrylmethane isolated as described in the first experiment; yield, 0.170 g. or 60% of tripyrrylmethane III, m. p. 190–191°. This experiment fails when commercial dioxane is used.

One hundred forty-two milligrams of tripyrrylmethane IV (0.00025 mole) and 64 mg. of aldehyde I (0.00025 mole) were dissolved by warming in 20 cc. of absolute dioxane and 10 mg. of potassium bisulfate was added. The solution turned an orange color. It was refluxed for thirty minutes and then poured into 200 cc. of ice and water containing 2 g. of sodium carbonate. A colorless solid precipitated which was filtered, washed and recrystallized from dilute ethanol; recovery, 0.130 g. or 91.5% of the tripyrrylmethane IV. The filtrate was acidified and cooled in ice. A colorless solid precipitated; recovery, 52 mg. or 81% of aldehyde I.

(d) **Cleavage of Tripyrrylmethane IV by Aldehyde I in Dilute Solution for Comparison with (b).**—Two hundred eighty-four milligrams (0.0005 mole) of tripyrrylmethane IV and 127 mg. (0.0005 mole) of aldehyde I¹⁰ were dissolved in 100 cc. of absolute ether by shaking. The conduct of the experiment was as described in (b). The first precipitate appeared after twelve and one-half minutes; yields: after twenty-five minutes, 54.8%; after eighty-five minutes, 15% additional; after one hundred forty-five minutes, 7% additional; total reaction time, one hundred forty-five minutes; total yield, 77%.

Condensations of 3,5,3'5'-Tetramethyl-4,4'-dicarbethoxydipyrrylmethene (Methene IX) and 2,4-Dimethyl-3-carbethoxy-pyrrole (Pyrrole II).—Two hundred fifty milligrams (0.00073 mole) of methene IX and 134 mg. (0.0008 mole) of pyrrole II were dissolved in 20 cc. of absolute dioxane by warming and the solution was then cooled to room temperature; 10 mg. of potassium bisulfate was added and the solution shaken for several minutes. The red color had faded to a light yellow in twenty minutes. The reaction was allowed to stand for a total time of one hundred fifty-five minutes and then poured into ice and water. The yellow solid was filtered off, dried in air and recrystallized from dilute ethanol; yield, 340 mg. or 91% of tripyrrylmethane X, m. p. 193–194°. A similar experiment was performed with the variation that the solution was refluxed for five minutes and then poured immediately into ice and water; yield, 96% of tripyrrylmethane X, m. p. 188–190°. Extraction of the product

(10) It should be noted that 0.0005 mole of these reagents is equivalent to 0.001 mole of the reagents in (b).

with toluene-hexane followed by repeated recrystallization from dilute ethanol raised the m. p. to 205–208°.

The experiment was repeated using ether as a solvent. This is not satisfactory because of the low solubility of the methene in ether. With no added catalyst the reaction proceeded slowly. Tripyrrylmethane X began to separate from the solution after forty minutes. The ether was evaporated on a steam-bath; yield, 97%, m. p. 191–192°.

With dioxane as solvent but with the substitution of hydrogen chloride for potassium bisulfate, only the hydrochloride of methene IX could be isolated; yield, 100% of a product melting with decomposition at 206°. This exactly parallels the cleavage of the tripyrrylmethane X which gave a copious precipitate of the salt of methene IX after five seconds and a quantitative yield when filtered after one minute.

An attempted condensation of 2,4-dimethyl-3-carbethoxy-5-formylpyrrole with 2,4-dimethyl-3-carbethoxy-pyrrole to give tripyrrylmethane X in dioxane with potassium bisulfate as catalyst was unsuccessful under the conditions which succeeded in giving tripyrrylmethane IV from the corresponding aldehyde.

Cleavage of Tripyrrylmethane IV with Hydrogen Chloride.—One and one-tenth grams of tripyrrylmethane IV was suspended in 185 cc. of dry ether and cooled in an ice-bath. Dry hydrogen chloride was passed in for ten minutes. The tripyrrylmethane dissolved with a light yellow color which rapidly gave way to orange. After two hours the solution was cherry-red. It was allowed to stand in an icebox and was wrapped with a towel to protect it from light. After two days it was deep violet but no crystals had appeared. After one month crystals had begun to appear on the walls of the vessel. The mixture was then allowed to warm up to room temperature and to stand for one year. The mother liquor was drained off and neutralized with calcium hydroxide and then chromatographed over alumina using carbon tetrachloride as

solvent. The colorless fore-runs contained a dissolved oil but no crystalline derivative was obtained from it.

The crystals on the wall of the vessel were dissolved in chloroform and chromatographed over calcium hydroxide to prepare the free base of the methene. The methene solution was evaporated to dryness and taken up in a mixture of 25% chloroform and 75% carbon tetrachloride (both solvents freshly treated with lime to remove acidic decomposition products). The methene layer developed below a much darker layer on the chromatogram and was separated and eluted with purified chloroform. The solution was evaporated in a weighed flask; yield, 0.223 g. or 33%. It was identified as methene IX by its decomposition point, 187°, and by hydrogenation to 3,5,3',5'-tetramethyl-4,4'-dicarbethoxy-dipyrrylmethane, m. p. 229°.

Summary

1. It has been discovered that dipyrromethenes react with pyrroles with free alpha positions to form tripyrrylmethanes.
2. Application of this reaction permits direct velocity comparisons which make it possible to study the mechanism of the formation of dipyrromethenes.
3. It has been demonstrated by actual isolation that a tripyrrylmethane is an intermediate in a "normal" dipyrromethene synthesis.
4. It is inferred from comparisons of velocity that this dipyrromethene is an intermediate in the formation of the tripyrrylmethane and is, therefore, an intermediate in its own formation.
5. Cleavage of a "stable" tripyrrylmethane by hydrogen chloride alone has been demonstrated.

BALTIMORE, MARYLAND

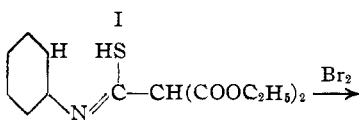
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[CONTRIBUTION FROM THE PEARSON MEMORIAL LABORATORY OF TUFTS COLLEGE]

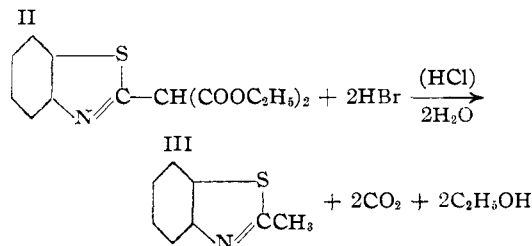
The Action of Bromine on Certain Thioamides

BY DAVID E. WORRALL AND ARTHUR W. PHILLIPS

The thioamide obtained by the action of two equivalents of *p*-tolyl isothiocyanate on ethyl acetonedicarboxylate reacts spontaneously with bromine.¹ In order to present a structural interpretation of the product formed here, a study of the action of bromine on the addition product of malonic ester and phenyl isothiocyanate is here reported. The course of the reactions involved can be outlined as follows



(1) Worrall, *This Journal*, **61**, 2986 (1939).



The product resulting from the loss of hydrogen bromide, and cyclization, forms a salt with alcoholic potassium hydroxide and also acts enolic toward a Grignard reagent. With hydrochloric acid, it undergoes hydrolysis and decarboxylation, to yield the well-known 1-methylbenzothiazole.