below the following conclusions seem justified.[12]

1. The use of a small amount of iodine to initiate the reaction decreases enolization.[13] In two experiments with ketone I and ethyl α-bromopropionate, 38% of acid[14] and 27% of ketone I were obtained when iodine was used. Without iodine the yields were 23% of acid[14] and 42% of ketone. In other experiments with ketone III and ethyl bromoacetate, when iodine was used 87% of acid and 6% of ketone III were isolated. Without iodine the yields were 77% of acid and 17% of ketone.

2. The use of dioxane as a solvent promotes enolization. In experiments with ketone I and ethyl bromoacetate, 68% of acid[14] and a small but undetermined amount of ketone were obtained in benzene as solvent. In pure dioxane the reaction took place more vigorously than in benzene but the yields were 29% of acid[14] and a large but undetermined amount of ketone I. No iodine was used. In other experiments with methyl bromoacetate and ketone II, when iodine was used in benzene, 52% of acid and 41% of ketone II were isolated. In dioxane and with no iodine the reaction was much more vigorous than in benzene but only 10% of acid and 70% of ketone were obtained.

3. The tendency to cause ketones to react by enolization increases in the following esters: ethyl bromoacetate <ethyl α-bromopropionate <ethyl α-bromobutyrate. In experiments with ketone I using no iodine, ethyl bromoacetate yielded 68% of acid[14] and a small amount of ketone, whereas ethyl α-bromopropionate yielded 23% of acid and 42% of ketone. In experiments with ketone I using iodine, ethyl α-bromopropionate yielded 38% of acid[14] and 27% of ketone I, whereas ethyl α-bromobutyrate yielded 28% of acid[14] and 48% of ketone I. In experiments with ketone III using no iodine, ethyl bromoacetate yielded 77% of acid and 17% of ketone III, whereas ethyl α-bromopropionate yielded 55% of acid and 39% of ketone III.

(12) It should be emphasized that the experiments cited were not isolated cases but those in which the results had been duplicated to within a few per cent. In all of these cases the zinc reacted approached the theoretical and in all cases the reactions had proceeded for a maximum of ninety minutes.

(13) The amount of enolization is probably more accurately estimated by the amount of ketone recovered than by the amount of acid isolated. Those cases where the total amount of products accounted for is less than 85% were from earlier work, where the technique was not as good as in later work.

(14) The percentages indicated in these cases represent pure crystalline acid only; additional non-crystalline acid was present but was not accounted for.

Summary

Evidence is presented that the recovery of starting ketone from the products of a Reformatsky reaction may be due to enolization of the ketone during reaction. In the case of acetomesitylene, 90% of the ketone is recovered after reaction. A few factors influencing the enolization of ketones in the Reformatsky reaction are discussed.

COLUMBUS, OHIO RECEIVED APRIL 24, 1942

[COMMUNICATION NO. 863 FROM THE KODAK RESEARCH LABORATORIES]

Investigation of Pyrazole Compounds. I. The Reaction Product of Phenylhydrazine and Ethyl Cyanoacetate

BY A. WEISSBERGER AND H. D. PORTER

Conrad and Zart[1] treated ethyl cyanoacetate with phenylhydrazine, using sodium alcoholate as a condensing agent, and obtained a colorless compound of the composition $C_9H_9N_3O$ and the m. p. 219°. This, they assumed to be 1-phenyl-3-hydroxy-5-pyrazolone-imide, I. However, the reaction between ethyl cyanoacetate and phenylhydrazine could also lead to the isomeric 1-phenyl-3-amino-5-pyrazolone, II. The intermediate in the formation of I might be the β-cyanoacetylphenylhydrazine, III, while the formation of β-imino-β-(β-phenylhydrazino)-propionic ester, IV, as the primary product would lead to II.

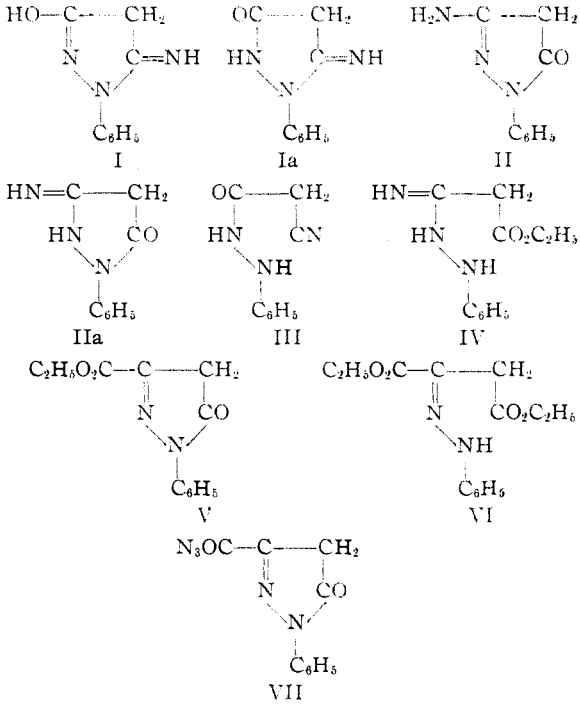
The compound synthesized by Conrad and Zart is of importance in color photography,[2] and it appeared desirable to get definite information about its structure. In order to decide between I and II, I was synthesized in an unambiguous way, starting with 1-phenyl-3-carbethoxy-5-pyrazolone, V.[3] This compound can be prepared by ring closure from the well-characterized ethyl

(1) Conrad and Zart, *Ber.*, **39**, 2282 (1906).

(2) British Patent 478,990.

(3) Wislicenus, *Ann.*, **246**, 319 (1888).

oxalacetate phenylhydrazone,[3] VI. V was transformed to the hydrazide and azide, VII, and the latter subjected to a Curtius degradation. The compound obtained is identical with that prepared according to Conrad and Zart. Hence, *the formulation of this compound as I is erroneous and has to be replaced by II.* The identity of the compound made from V with that prepared according to Conrad and Zart was proved by m. p. and mixed m. p., and by the identical behavior of the two substances in the reactions leading to and the m. p.'s and mixed m. p.'s of the monobenzoyl derivative, the monocarbethoxy derivative and



the reaction product with aniline described below. Both I and II are capable of forming by prototropic shift, equilibria with tautomeric forms, *e. g.*, I with Ia, and II with IIa, and the same applies to the derivatives described below. However, the family of I differs from that of II by the position of the phenyl group, and the two families are not subject to tautomeric interchange. In the following, all compounds which by prototropic shift could form derivatives of pyrazolone will be named as such.

Treatment of II with one mole of benzoyl chloride yields a monobenzoyl derivative which is soluble in aqueous sodium carbonate. A monocarbethoxy derivative of similar behavior is obtained by treatment of II with ethyl chlorocarbonate. The same compound is formed by decomposition of the azide VII in boiling ethanol, which shows that it is 1-phenyl-3-carbethoxyamino-5-pyrazolone. By analogy, the monobenzoyl derivative is 1-phenyl-3-benzoylamino-5-pyrazolone. With phenyl isocyanate II forms a compound of the composition $C_{16}H_{14}N_4O_2$ which is soluble in aqueous sodium carbonate, and, in analogy to the two derivatives just mentioned, is formulated as 1-phenyl-3-phenylcarbamylamino-5-pyrazolone. Treatment of II with one mole of acetyl chloride yields a monoacetyl derivative, behaving like the other monoacyl derivatives. The compound, therefore, is formulated as 1-phenyl-3-acetylamino-5-pyrazolone, IX. Acetylation with excess acetic anhydride gives a diacetyl derivative which is insoluble in carbonate. The second acetyl group is very easily split off by caustic alkali forming IX, and the diacetyl derivative, therefore, is most likely the 1-phenyl-3-acetamino-5-acetoxy-pyrazole. On heating II with aniline, ammonia is split off and C_6H_5NH is introduced. The compound so obtained is soluble in aqueous sodium carbonate. It is, most likely, the 1-phenyl-3-phenylamino-5-pyrazolone.

Experimental

1-Phenyl-3-amino-5-pyrazolone (Method of Conrad and Zart[1]).—To a solution of sodium ethylate prepared from 4.6 g. of sodium and 80 ml. of absolute ethanol, was added 11.3 g. of ethyl cyanoacetate and 10.8 g. of phenylhydrazine. The mixture was heated under reflux in an oil-bath of 120° for sixteen hours. After removal of the alcohol under vacuum, the residue was dissolved in 100 ml. of water and extracted with 50 ml. of ether. The aqueous layer, on acidification with 10 ml. of acetic acid, deposited 8.3 g. of a tan powder, sintering at 208° and melting at 213–215° dec. The product was purified by boiling with 50 ml. of 95% ethanol, cooling, filtering and washing with 10 ml. of ethanol; 7.6 g. (43%), m. p. 216–218° dec. This material is sufficiently pure for the preparation of derivatives. It can be recrystallized from 10 parts of ethanol–dioxane (2:1). After three recrystallizations, including treatment with Norite, small white prisms were obtained, m. p. 218–220°.

At least two equivalents of sodium ethylate are necessary for the reaction, but larger amounts do not improve the yields, which are the highest, if equal moles of phenylhydrazine and ethyl cyanoacetate are employed.[4]

1-Phenyl-3-amino-5-pyrazolone from 1-Phenyl-3-carbethoxy-5-pyrazolone

1-Phenyl-3-carbethoxy-5-pyrazolone was synthesized following, in principle, the method of Wislicenus.[3] A solution of 60 g. of ethyl oxalacetate phenylhydrazone[3] in

(4) These results were obtained in a series of experiments by E. C. Armstrong of these Laboratories. The authors wish to thank Mr. Armstrong for his assistance.

250 ml. of benzene and 10 ml. of glacial acetic acid was heated under reflux for three hours. The product obtained after cooling was washed on the filter with 25 ml. of benzene; 40 g. (80%) of white, feathery needles, m. p. 185–186°.

In the absence of acetic acid no 1-phenyl-3-carbethoxy-5-pyrazolone was formed even though the heating time was doubled, while refluxing in xylene for three hours in the absence of acid gave a yield of 28%. When phenylhydrazine was added gradually to a boiling solution of ethyl oxalacetate in xylene, and water and alcohol were distilled off as they formed, yields of only about 40% were obtained. A yield of 54% was obtained when the phenylhydrazone was heated in about 10 parts of water.

1-Phenyl-5-pyrazolone-3-carboxamide.—Twenty grams of 1-phenyl-3-carbethoxy-5-pyrazolone was stirred in 200 ml. of concentrated ammonium hydroxide (28%) until a clear solution was formed and then left standing for ninety-six hours at room temperature. The solution was acidified with 30% acetic acid to give 15 g. (86%) of almost white crystals which darkened at 215° and melted at 228° dec., recrystallized from 200 ml. of 95% ethanol; 10 g. (57%) of white crystals, m. p. 233–235° dec.

Anal. Calcd. for $C_{10}H_9N_3O_2$: N, 20.7. Found: N, 20.14.

1-Phenyl-5-pyrazolone-3-carboxhydrazide.—A mixture of 34 g. of 1-phenyl-3-carbethoxy-5-pyrazolone and 100 ml. of 42% hydrazine hydrate solution was stirred at room temperature. The solution warmed spontaneously to *ca.* 40° and became clear. After standing for four hours an equal volume of water was added. On acidification with acetic acid, 27.5 g. (86%) of fine, cream colored needles separated, m. p. 235–237° dec. The melting point was not changed by recrystallization from ethanol.

Anal. Calcd. for $C_{10}H_{10}N_4O_2$: N, 25.65. Found: N, 25.19.

1-Phenyl-5-pyrazolone-3-carboxazide.—To a solution of 10 g. of 1-phenyl-5-pyrazolone-3-carboxhydrazide in 200 ml. of 70% ethanol containing 6 ml. of concentrated hydrochloric acid, was added dropwise with stirring 2.3 g. of sodium nitrite in 10 ml. of water, while keeping the temperature below 5°. Stirring was continued at this temperature for one hour. The product was filtered and washed with water; 6.5 g. (62%) of granular orange powder, deflagrating at 140°.

1-Phenyl-3-carbethoxyamino-5-pyrazolone.—A solution of 3 g. of 1-phenyl-5-pyrazolone-3-carboxazide in 30 ml. of absolute ethanol was refluxed for three hours, cooled and filtered; 2 g. (63%) of yellowish crystals, m. p. 197–199°, recrystallized from 70 cc. of 95% ethanol (Norite); white needles, m. p. 198–199°. A mixed m. p. with the 1-phenyl-3-carbethoxyamino-5-pyrazolone described below showed no depression.

1-Phenyl-3-amino-5-pyrazolone.—A solution of 2.5 g. of 1-phenyl-3-carbethoxyamino-5-pyrazolone in 12.5 ml. of 10% sodium hydroxide was heated on the steam-bath for half an hour, then cooled and acidified with acetic acid; 1.4 g. (m. p. 215–216° dec.) of tan crystals, recrystallized from 95% ethanol, small, white prisms; m. p. 218–220° dec. A mixed m. p. with the compound prepared by the method of Conrad and Zart, showed no depression.

Other reactions attempted in the preparation of 1-phenyl-3-amino-5-pyrazolone were given up after the success of the Curtius degradation. The conventional Hofmann degradation of 1-phenyl-5-pyrazolone-3-carboxamide gave uninviting brominated products. When the sodium salt of 1-phenyl-3-chloro-5-pyrazolone[5] was treated with potassium phthalimide in boiling alcohol for twenty hours, or with sodium amide in liquid ammonia at −33° for forty hours, the unchanged starting material was recovered. Treatment with sodium amide in ammonia at 100° under pressure for twenty hours gave no water-insoluble product. The starting material was recovered after treatment of 1-phenyl-5-pyrazolone-3-carboxylic acid with hydrazoic acid in the presence of sulfuric acid following the method of von Braun.[6]

Derivatives of 1-Phenyl-3-amino-5-pyrazolone

1-Phenyl-3-benzoylamino-5-pyrazolone.—A mixture of 5 g. of 1-phenyl-3-amino-5-pyrazolone[7] and 4 g. of benzoyl chloride in 20 ml. of dioxane was stirred and heated on the steam-bath for eighteen hours. The product which crystallized after addition of 5 ml. of water, was purified by slurrying with 15 ml. of methanol; 5 g. (64%) of fine, cream colored needles, m. p. 218–220°, recrystallized from 15 parts of dioxane, m. p. 220–221°.

Anal. Calcd. for $C_{16}H_{13}N_3O_2$: N, 15.06. Found: N, 14.95.

The compound is soluble in 3% sodium carbonate or 2% sodium hydroxide. It is recovered unchanged on acidification with acetic acid.

1-Phenyl-3-carbethoxyamino-5-pyrazolone.—A mixture of 8.75 g. of 1-phenyl-3-amino-5-pyrazolone and 5.4 g. of ethyl chlorocarbonate in 35 ml. of dioxane was stirred and heated on the steam-bath for three and one-half hours. On addition of 5 ml. of water and cooling, 1.5 g. of tan crystals separated, recrystallized from 50 ml. of 95% ethanol; 1 g. of fine white needles, m. p. 198–199°.

Anal. Calcd. for $C_{12}H_{13}N_3O_3$: N, 17.00. Found: N, 16.97.

When the filtrate was diluted with an equal volume of water, 4.6 g. of a tan crystalline product separated which, after recrystallization from 15 ml. of 95% ethanol gave 3 g. of tan crystals, m. p. 106–108°. This product, probably a dicarbethoxy derivative, on heating under reflux in 65 ml. of absolute alcohol with 1 ml. of piperidine for one-half hour yielded 1.2 g. of the 1-phenyl-3-carbethoxy-amino-5-pyrazolone, m. p. 198–199°.

1-Phenyl-3-acetylamino-5-pyrazolone.[4]—To a suspension of 8.75 g. of 1-phenyl-3-amino-5-pyrazolone in 50 ml. of dioxane was added all at once while stirring 5.5 g. of acetyl chloride. The solution formed was warmed in a water-bath at 40° for one hour, cooled, the product collected on the filter and recrystallized from 30 ml. of 95% ethanol; 4.5 g. (43%) of short, white needles, m. p. 218–220°. The m. p. is the same as that of the starting material; however, a mixed m. p. was depressed by about 30–40°.

Anal. Calcd. for $C_{11}H_{11}N_3O_2$: N, 19.35. Found: N, 19.44.

(5) Michaelis and Röhmer, *Ber.*, **31**, 3003 (1898).
(6) von Braun, *Ann.*, **490**, 125 (1931).
(7) Prepared by either method given above.

Toward carbonate and hydroxide solutions the compound behaves like the 1-phenyl-3-benzoylamino-5-pyrazolone.

1-Phenyl-3-acetylamino-5-acetoxypyrazole.[4]—A solution of 8.75 g. of 1-phenyl-3-amino-5-pyrazolone in 50 ml. of acetic anhydride was refluxed for half an hour. After decomposing the mixture in 250 ml. of water, the product was filtered off and recrystallized from 90 ml. of toluene; 8 g. (62%) of fine, cream colored crystals; m. p. 144–145°.

Anal. Calcd. for $C_{13}H_{13}N_3O_2$: N, 16.22. Found: N, 16.12.

The compound is insoluble in 3% sodium carbonate. It dissolves in cold 2% sodium hydroxide with saponification of one acetyl group; on acidification with acetic acid 1-phenyl-3-acetylamino-5-pyrazolone is obtained; m. p. and mixed m. p. 218–220°.

1-Phenyl-3-phenylcarbamylamino-5-pyrazolone.—To a hot solution of 5 g. of 1-phenyl-3-amino-5-pyrazolone in 20 ml. of dioxane was added 3.4 g. of phenyl isocyanate and the mixture heated for two hours on the steam-bath. The product which crystallized on cooling was purified by stirring with 25 ml. of ethanol; 2.3 g. (28%) of pure white microcrystals, m. p. 235–236°.

Anal. Calcd. for $C_{16}H_{14}N_4O_2$: N, 19.0. Found: N, 19.00.

Toward carbonate and hydroxide solutions the compound behaves like the 1-phenyl-3-benzoylamino-5-pyrazolone.

1 Phenyl-3-anilino-5-pyrazolone.—A mixture of 20 g. of 1-phenyl-3-amino-5-pyrazolone[7] and 50 ml. of aniline was refluxed gently over a flame for one and one-half hour, *i. e.*, until the evolution of ammonia slacked off. After some cooling, 100 ml. of chloroform was added and the solution cooled in an ice-bath. The product (14.6 g.) was recrystallized from 300 ml. of 95% ethanol, filtering hot from a small amount of insoluble yellow material; 12 g. (43%) of white, feathery needles, m. p. 219–221°.

Anal. Calcd. for $C_{15}H_{13}N_3O$: N, 16.70. Found: N, 16.77.

The compound is sparingly soluble in cold 3% sodium carbonate, but soluble in cold 2% sodium hydroxide, from which it separates unchanged on acidification.

Summary

1. 1-Phenyl-3-amino-5-pyrazolone was prepared, starting with the ethyl ester of 1-phenyl-3-carboxy-5-pyrazolone, by way of the corresponding hydrazide and azide and Curtius degradation of the latter.

2. The reaction product is identical with the compound prepared by Conrad and Zart[1] from ethyl cyanoacetate and phenylhydrazine and formulated as 1-phenyl-3-hydroxy-5-pyrazolone imide.

3. The compound prepared by Conrad and Zart is, therefore, 1-phenyl-3-amino-5-pyrazolone.

4. A number of derivatives of 1-phenyl-3-amino-5-pyrazolone were prepared.

ROCHESTER, N. Y. RECEIVED JUNE 24, 1942

[CONTRIBUTION FROM THE NOYES CHEMICAL LABORATORY, UNIVERSITY OF ILLINOIS]

The Reaction of Methyl Furoate with Benzene and Chlorobenzene

BY CHARLES C. PRICE AND C. F. HUBER

The aluminum chloride-catalyzed reaction of furoic acid with benzene has been found to yield, in addition to α-naphthoic acid,[1] a large amount of an amorphous mixture of acids of higher molecular weight.[2] Although some suggestions as to the nature of certain components of this material were advanced on the basis of degradation products of the crude mixture, the isolation of any pure acids has proved extremely difficult. Since attempts at fractional crystallization or precipitation of the acids or of various derivatives were so generally unsuccessful, the condensation reaction has been investigated employing methyl furoate in place of furoic acid, with the aim of separating by distillation the esters so formed.

(1) Gilman, McCorkle and Calloway, THIS JOURNAL, **56**, 745 (1934).

(2) Price, Chapin, Goldman, Krebs and Shafer, *ibid.*, **63**, 1857 (1941).

McCorkle and Turck[3] were able to isolate a 56% yield of methyl α-naphthoate from the aluminum chloride-catalyzed reaction of methyl furoate with benzene, and Calloway[4] reported that a considerable residue remained after distillation of the naphthoate. We have obtained the same results, isolating methyl α-naphthoate in 32–46% yield accompanied by a residue of higher-boiling products.

Fractional distillation of this residue under the vacuum of a mercury vapor pump yielded a pale yellow, viscous oil, boiling at 144–145° (0.04 mm.), which crystallized after standing for seven months, m. p. 52–54°. The yield of this substance, which proved to be methyl 9-ethyl-9,10-dihydro-9-anthroate (II), corresponded to 11–20% of the theoretical amount.

(3) McCorkle and Turck, *Proc. Iowa Acad. Sci.*, **43**, 205 (1936).

(4) Calloway, *Chem. Rev.*, **17**, 343 (1935).