CXII.—*The Condensation of Amides with Esters of Acetylenic Acids.*

By SIEGFRIED RUHEMANN.

SOME years ago, it was shown (Ruhemann and Merriman, *Trans.*, 1905, **87**, 1383) that phenylpropiolyl chloride reacts with sodioacetylacetone to form a yellow compound, $C_{14}H_{12}O_3$ (I), which has the remarkable property of changing under the influence of piperidine into a blue salt of a red isomeride (II), and that the latter on digestion with sodium carbonate is transformed into a colourless acid (III), isomeric with the other two substances. These compounds were represented thus:

With the view of preparing analogous heterocyclic substances containing nitrogen, I have treated phenylpropiolyl chloride with sodiobenzamide; but this reaction, instead of taking place in the manner similar to the formation of the furan derivative (I) and yielding phenylbenzylideneoxazolone,

furnishes diphenylpropiolylbenzamide, $(C_6H_5 \cdot C:C \cdot CO)_2N \cdot CO \cdot C_6H_5$. This result corresponds with the behaviour of benzoyl chloride towards sodiobenzamide, which, as Curtius (*Ber.*, 1890, **23**, 3040) showed, yields tribenzamide.

The interaction of ethyl phenylpropiolate and sodiobenzamide leads near to the desired end. This method has been used before (see

Curtius, *Ber.*, 1890, **23**, 3038 ; Titherley, *Trans.*, 1902, **81**, 1520) for the formation of diacylimides, and has since been applied by Ruhemann and Priestley (*Trans.*, 1909, **95**, 449) for the production of acyl derivatives of ethyl carbamate. The oxazolone compound, which, most probably, is first formed, cannot, however, be isolated, because, under the prevailing conditions, it suffers a transformation similar to the one which the furan derivative (I) undergoes to its red isomeride (II), and yields a deep red compound, $C_{16}H_{11}O_2N$. This is to be represented thus :

and, therefore, to be called *diketodiphenylpyrroline*. Along with the cyclic compound, a colourless substance, $C_{23}H_{18}O_3N_2$, is produced, which undoubtedly owes its formation to the union of phenylpropionylbenzamide with benzamide. It has, therefore, the constitution $C_6H_5\cdot C(\text{NH}\cdot\text{CO}\cdot C_6H_5)\cdot\text{CH}\cdot\text{CO}\cdot\text{NH}\cdot\text{CO}\cdot C_6H_5$, which characterises it as the *benzamide* of β -benzoylaminocinnamic acid.

The correctness of the view concerning the constitution of the compound, $C_{16}H_{11}O_2N$, follows from the fact that, on boiling with potassium hydroxide, it decomposes quantitatively, thus :

and furnishes deoxybenzoin, besides ammonia and oxalic acid. Diketodiphenylpyrroline dissolves in dilute alkalis to yield blue solutions, which, however, rapidly turn yellow ; on adding dilute hydrochloric acid, the red pyrroline derivative is precipitated unchanged. This behaviour resembles that of isatin in forming violet solutions with alkalis, which change to yellow and then contain the salts of isatoic acid. Like isatin, diketodiphenylpyrroline forms a phenylhydrazone which is insoluble in alkalis or acids. As may be expected, both compounds differ in their behaviour towards reducing agents. Whereas isatin, on treatment of its solution in glacial acetic acid with zinc dust, yields isatide, $C_{16}H_{12}O_4N_2$, diketodiphenylpyrroline, under the same conditions, is reduced to *diketodiphenylpyrrolidine* $\begin{array}{c} \text{CO}-\text{CO} \\ | \\ \text{CHPh}\cdot\text{CHPh} \end{array} \text{ > NH}$. Diketodiphenylpyrroline (V) not only resembles isatin (IV), but also the red *cyclopentene* derivative (VI), and this resemblance follows both from the similarity of their formation and from their property of yielding blue salts. This fact, in turn, supports the constitution of the latter substance. There can neither be any doubt as to the relation of these compounds with triethyloxalylaconitate (VII), which Ruhemann and Hemmy (*Trans.*, 1897, **71**, 34) obtained from ethyl oxaloacetate, and to Claisen and Ewan's oxalyl

dibenzyl ketone (VIII) (*Annalen*, 1895, **284**, 245). [View Article Online](#)
 between these substances finds its full expression in their formulæ :

As to the constitution of the violet or blue salts which these compounds form, Claisen and Ewan (*loc. cit.*) expressed the view that the blue disodio-derivative of oxalyldibenzyl ketone is probably to be formulated as (IX), whereas Ruhemann and Merriman (*loc. cit.*) represented the blue salt of the cyclopentene derivative (VI) by formula (X) :

The following considerations, however, lead to the conclusion that neither view is correct. Von Baeyer, in the course of his classical researches on the indigo group, showed that the ethyl ether of ψ -isatin- α -oxime, $\text{C}_6\text{H}_4 \begin{array}{c} \text{CO} \\ \diagup \quad \diagdown \\ \text{NH} \end{array} \text{C} \cdot \text{NOEt}$, with sodium hydroxide yields a blue salt similar to the one which the indogenide of benzaldehyde, $\text{C}_6\text{H}_4 \begin{array}{c} \text{CO} \\ \diagup \quad \diagdown \\ \text{NH} \end{array} \text{C} \cdot \text{CH} \cdot \text{C}_6\text{H}_5$, forms. It follows, therefore, that the replacement of the oxygen of the α -ketonic group in ψ -isatin by a bivalent group does not interfere with the formation of a blue salt.

The result is different, however, if the oxygen of the β -ketonic group of ψ -isatin is substituted by such a group, as in the ethyl ether of isatoxime, $\text{C}_6\text{H}_4 \begin{array}{c} \text{C}(\text{NOEt}) \\ \diagup \quad \diagdown \\ \text{NH} \end{array} \text{CO}$. In this case, a blue salt is not formed. This result indicates that the metal is not attached to the nitrogen of the imino-group, as von Baeyer suggests, but to the oxygen of the β -ketonic group. It follows, therefore, that isatin in its violet salts appears in its tautomeric form, $\text{C}_6\text{H}_4 \begin{array}{c} \text{C}(\text{OH}) \\ \diagup \quad \diagdown \\ \text{N} \end{array} \text{CO}$, and this

grouping will be found in the salts of those derivatives in which the oxygen of the α -ketonic group is replaced by bivalent radicles. In this form isatin appears as an orthoquinone derivative. Owing to the similarity which exists between isatin and the above-mentioned compounds, the view is justified that their salts have an analogous constitution; for instance, corresponding with (V) and (VI):

It may be mentioned that in the case of pyrrole, previous investigators have been obliged to consider the possibility of its existing in a tautomeric form, for pentachloropyrrole is undoubtedly derived from the tautomeride (XI), which, according to the above remarks, would exist, also, in the salts of diketodiphenylpyrroline.*

The reaction of ethyl phenylpropiolate with sodiobenzamide seems to be typical of the behaviour of the sodium derivatives of aromatic amides with the esters of acetylenic acids. This would follow from the fact that sodio-*o*-toluamide yields diketophenyl-*o*-tolylpyrroline,

which closely resembles its lower homologue. The sodium derivatives of fatty or fatty-aromatic amides, however, do not condense with ethyl phenylpropiolate to cyclic substances, instead diacylimides are formed, as phenylpropiolylphenylacetamide,

from the acetylenic ester and sodiophenylacetamide.

EXPERIMENTAL.

Diphenylpropiolylbenzamide, $(\text{C}_6\text{H}_5\cdot\text{C}:\text{C}\cdot\text{CO})_2\text{N}\cdot\text{CO}\cdot\text{C}_6\text{H}_5$.

As stated in the introduction, this compound is formed by the action of phenylpropiolyl chloride on sodiobenzamide. The latter substance was prepared according to Blacher's method (*Ber.*, 1895, 28, 432) by evaporating the absolute alcoholic solution of the mixture of sodium ethoxide and benzamide in a vacuum, first from the water-

* The relation which exists between the above-named substances may be extended to other classes of compounds which, like violuric acid, form coloured salts. Their structure:

indicates a certain resemblance to the constitution of the metallic derivatives of diketodiphenylpyrroline and its analogues; for it also has an orthoquinone grouping and the same relative position of the metal in the molecules of the salts (see also Hantzsch and Isherwood, *Ber.*, 1909, 42, 986).

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bath and finally from the oil-bath, which is gradually heated to 200°. On adding phenylpropiolyl chloride (8.2 grams) to the dry sodiobenzamide (7.1 grams), suspended in benzene, heat is developed. The mixture, after being kept for a short time at the ordinary temperature, is digested on the water-bath for about half an hour, the benzene is evaporated, and the dark-coloured residue washed with ether, when a faintly-coloured solid remains undissolved. This is soluble in a large amount of boiling alcohol, and, on cooling, separates in almost colourless needles melting at 242°:

0.1955 gave 0.5692 CO₂ and 0.0745 H₂O. C = 79.40; H = 4.23.

0.2082 „ 7 c.c. N₂ at 19° and 743 mm. N = 3.78.

C₂₅H₁₅O₃N requires C = 79.57; H = 3.98; N = 3.71 per cent

Action of Sodiobenzamide on Ethyl Phenylpropiolate.

On mixing finely-powdered sodiobenzamide (7.1 grams), suspended in dry benzene, with ethyl phenylpropiolate (8.7 grams), no visible change takes place at the ordinary temperature, but an action sets in, which is indicated by the development of a deep blue coloration, if the mixture is heated on the water-bath for a short time. After an hour's digestion, the benzene is evaporated, and the residue treated with water, when the blue colour disappears. The whole is then agitated with ether, which extracts small quantities of unaltered benzamide and ethyl phenylpropiolate, and the aqueous layer is mixed with an excess of dilute hydrochloric acid. An oil separates which, on removal of the dissolved ether, sets to a solid. This is a mixture of the deep red diketodiphenylpyrroline and the colourless benzamide of β -benzoylamino-cinnamic acid. These compounds differ but slightly in the degree of solubility in organic solvents; they dissolve, also, in dilute potassium hydroxide or sodium carbonate; their separation, therefore, presented great difficulties until it was found that, on saturating the alkaline solutions of the mixture with carbon dioxide, the colourless compound is precipitated, but not the coloured diketodiphenylpyrroline.

The Benzamide of β -Benzoylamino-cinnamic Acid,

separates, on passing carbon dioxide through the solution of the product of the reaction in dilute potassium hydroxide, as a light red solid, which, when washed with a little dilute alcohol, becomes colourless. It is insoluble in water, but readily dissolves in glacial acetic acid, ethyl acetate, ether, or hot alcohol, and, on cooling its solution in boiling dilute alcohol, crystallises in needles, which melt at 188° to a red liquid:

0.1950 gave 0.5370 CO₂ and 0.0890 H₂O. C = 75.10; H = 5.07. [View Article Online](#)

0.1840 „ 12.4 c.c. N₂ at 18° and 748 mm. N = 7.65.

C₂₃H₁₈O₃N₂ requires C = 75.13; H = 4.86; N = 7.57 per cent.

Diketodiphenylpyrroline, $\begin{array}{c} \text{CO} \text{---} \text{CO} \\ | \qquad \qquad | \\ \text{CPh} : \text{CPh} \end{array} \text{>NH}$, is contained in the pale

yellow filtrate from the former compound. On adding dilute hydrochloric acid, a faintly-coloured emulsion is first produced, which is shortly transformed into a red solid. This is scarcely soluble in boiling water, but just sufficiently to yield a red solution; it is readily soluble in ether, acetone, or alcohol, and, on cooling its concentrated solution in hot alcohol, separates in beautiful, deep red needles, which melt and decompose at 184°:

0.1960 gave 0.5537 CO₂ and 0.0820 H₂O. C = 77.04; H = 4.64.

0.2452 „ 12 c.c. N₂ at 20° and 764 mm. N = 5.62.

C₁₆H₁₁O₃N requires C = 77.11; H = 4.42; N = 5.62 per cent.

Diketodiphenylpyrroline dissolves in dilute potassium hydroxide to yield a deep blue solution, which rapidly turns yellow; this, no doubt, contains the salt of aminostilbeneoxalic acid,

for, on adding dilute hydrochloric acid, a faintly-coloured emulsion is first produced, which, however, readily loses water and condenses to diketodiphenylpyrroline. This reaction, therefore, resembles the behaviour of alkalis towards isatin.

On boiling diketodiphenylpyrroline with an excess of dilute potassium hydroxide, it is decomposed and yields ammonia, oxalic acid, and deoxybenzoin. The heating is continued until the evolution of ammonia ceases; the deoxybenzoin which separates is collected and recrystallised from dilute alcohol, when it is obtained in colourless needles, which are volatile with steam and melt at 60°:

0.1657 gave 0.5200 CO₂ and 0.0925 H₂O. C = 85.59; H = 6.20

C₁₄H₁₂O requires C = 85.71; H = 6.12 per cent.

The yield of deoxybenzoin amounts to 90 per cent. of the theoretical. The alkaline filtrate from this product of the decomposition of diketodiphenylpyrroline contains oxalic acid, which was isolated in the form of its calcium salt

The Phenylhydrazone of Diketodiphenylpyrroline,

Like isatin, diketodiphenylpyrroline readily forms a phenylhydrazone if its alcoholic solution is boiled with phenylhydrazine on the water-bath. It separates from the hot solution as a red, crystal-

line solid, which is soluble in hot benzene ; it is almost insoluble in cold alcohol, but it dissolves in a large volume of boiling alcohol, and, on cooling, crystallises in vermilion needles, which melt and decompose at 231° :

0.1827 gave 19.8 c.c. N_2 at 19° and 759 mm. $N = 12.43$.

$C_{22}H_{17}ON_3$ requires $N = 12.36$ per cent.

Reduction of Diketodiphenylpyrroline.

On adding zinc dust to the hot solution of diketodiphenylpyrroline in glacial acetic acid, the red colour is quickly discharged, and the colourless filtrate yields a white precipitate on the addition of water. This is fairly soluble in hot dilute alcohol, and, on cooling, crystallises in faintly-yellow needles, which turn brown at about 165° , and at $233-234^{\circ}$ melt to a dark liquid :

0.1907 gave 0.5338 CO_2 and 0.0905 H_2O . $C = 76.34$; $H = 5.27$.

0.2072 „ 10.4 c.c. N_2 at 19° and 744 mm. $N = 5.64$.

$C_{16}H_{18}O_2N$ requires $C = 76.49$; $H = 5.18$; $N = 5.58$ per cent.

The compound, which most probably is to be regarded as diketodiphenylpyrrolidine,

yields a deep bluish-green coloration on the addition of ferric chloride to its alcoholic solution.

Sodio-*o*-toluamide behaves similarly to sodiobenzamide in its action on ethyl phenylpropiolate. The reaction in this case was carried out as follows. *o*-Toluamide (6.5 grams) is dissolved in absolute ether (of which a large quantity is required, as the amide is but sparingly soluble in this solvent), and the solution digested with sodium wire (1.1 gram) on the water-bath. In the course of a day the metal disappears ; ethyl phenylpropiolate (8.4 grams) is then added, and the digestion continued. The mixture shortly turns blue ; after about an hour the ether is evaporated, and, in order to complete the reaction, the residue is mixed with dry benzene and digested for a short time.

The benzene is finally distilled from the water-bath and water added to the product, when the blue colour disappears. After removal of the unaltered toluamide and ethyl phenylpropiolate by extraction with ether, an excess of dilute hydrochloric acid is added to the aqueous layer, which precipitates a dark red substance. This is dissolved in cold dilute potassium hydroxide, and the solution

saturated with carbon dioxide. As in the case of the same treatment of the product which is formed from sodiobenzamide and ethyl phenylpropiolate, a yellowish-red solid is precipitated. I have not examined it, but there cannot be any doubt that it has the formula,

The pale yellow filtrate from this substance, on the addition of dilute hydrochloric acid, yields a red compound, *diketophenyl-o-tolylpyrroline*, which is readily soluble in ether or alcohol and crystallises from its concentrated alcoholic solution in beautiful deep red prisms melting at 165—166°:

0.1919 gave 0.5445 CO₂ and 0.0860 H₂O. C = 77.38; H = 4.95.

0.2140 „ 10.2 c.c. N₂ at 19° and 757 mm. N = 5.45.

C₁₇H₁₃O₂N requires C = 77.57; H = 4.94; N = 5.32 per cent.

This substance closely resembles diketodiphenylpyrroline; it dissolves in dilute potassium hydroxide, yielding a blue solution which rapidly turns yellow. With phenylhydrazine it forms the *phenylhydrazone*, C₁₇H₁₃ON:N·NH·C₆H₅, which separates in red crystals if the alcoholic solution of the pyrroline is digested with phenylhydrazine on the water-bath for one to two hours and then cooled. It is sparingly soluble in cold, moderately so in boiling, alcohol, and, on cooling, crystallises in scarlet prisms, which melt at 201—202°:

0.2068 gave 21.6 c.c. N₂ at 19° and 753 mm. N = 11.89.

C₂₃H₁₉ON₃ requires N = 11.90 per cent.

Action of Ethyl Phenylpropiolate on the Sodium Derivatives of Fatty and Fatty-aromatic Amides.

I have mentioned before (p. 987) that this reaction differs from that which occurs in the condensation of the acetylenic ester with the sodium compounds of aromatic amides, inasmuch as condensation to pyrroline derivatives does not take place, but diacylimides are produced.

Phenylpropiolylphenylacetamide, C₆H₅·C:C·CO·NH·CO·CH₂·C₆H₅.

Sodiophenylacetamide was prepared by Blacher's method (*loc. cit.*), by evaporating the alcoholic solution of the mixture of phenylacetamide and sodium ethoxide in a vacuum, first on a water-bath and then up to 200° on an oil-bath. To the powdered sodium compound (8 grams), suspended in dry benzene, ethyl phenylpropiolate (8.7 grams) is added, and the mixture boiled on the water-bath for an hour. The benzene is evaporated, and the brown, viscous residue treated with water and ether, when the whole dissolves. After removal of the

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etheral layer, dilute hydrochloric acid is added to the dark aqueous solution, when a yellow oil is precipitated which partly sets to a solid. This is washed with cold alcohol and dissolved in boiling alcohol; from the concentrated solution, on cooling, yellow prisms separate, which melt at 209—210°:

0.1848 gave 0.5255 CO_2 and 0.0847 H_2O . $\text{C} = 77.55$; $\text{H} = 5.09$.

0.2245 „ 10.8 c.c. N_2 at 20° and 758 mm. $\text{N} = 5.48$.

$\text{C}_{17}\text{H}_{13}\text{O}_2\text{N}$ requires $\text{C} = 77.57$; $\text{H} = 4.94$; $\text{N} = 5.32$ per cent.

I have ascertained, also, that sodioacetamide, when suspended in dry ether or benzene and digested with ethyl phenylpropiolate, does not yield a coloured compound which has properties similar to diketodiphenylpyrroline, but forms an almost colourless substance which is sparingly soluble in alcohol. This I have not further examined, but there cannot be any doubt that it is phenylpropiolylacetamide.

I am engaged in the continuation of the study of the pyrroline derivatives described above, and also in the investigation of the action of amides on esters of other acetylenic acids.

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