574. *Some New Mesoionic Compounds.*

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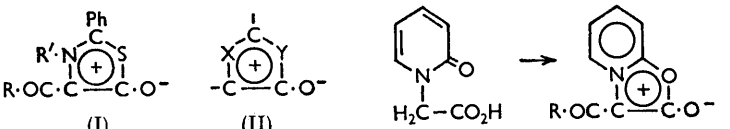
Mesoionic compounds belonging to the systems [II; X = N, Y = S; X = N, Y = O; X = N (of pyridine), Y = N; X = N, Y = NPh] have been prepared from *N*-substituted thiobenzoylglycines, 1,2-dihydro-2-oxo-1-pyridylacetic acid, *N*-substituted *N*-2-pyridylglycines, and *N*-(*N*-phenylbenzimidoyl)aminoacetic acids respectively. Some of their properties are described.

LAWSON and SEARLE [1] treated *N*-alkyl-*N*-thiobenzamido-acids with acid anhydrides and obtained products formulated as mesoionic compounds (I; R = Me, Et, R′ = Me, Et). In continuation of this work [2] the general system (II) has been studied, the hetero-atoms or -groups being varied: X = N, Y = S; X = N, Y = O; X = N (of pyridine), Y = N; X = N, Y = NPh. Mesoionic compounds corresponding to each of these systems have been prepared and their general properties and ultraviolet spectra recorded. The formulation adopted is that put forward by Baker and Ollis.[3,4] The tautomeric forms possible are restricted to those in which the cyclic carbonyl group is totally polarised, in order that the six π-electrons required for the ring to assume an aromatic character are to be available. However, infrared spectroscopic data [1] show that for anhydro-(4-acetyl-5-hydroxy-3-methyl-2-phenylthiazolium hydroxide) (I; R = R′ = Me) this is only partially justified.

Katritzky's nomenclature [5] has been adopted in this communication.



(I) (II) (III) (IV)

The range of compounds of the type (I) was extended by the preparation of the *N*-phenyl and the *C*-benzoyl derivative (I; R = Me, Ph; R′ = Me, Ph). Thiobenzoyl-*N*-phenylglycine cyclised very readily when warmed with acid anhydrides. Ring-closure with *C*-benzoylation was achieved by heating the acid with benzoyl chloride and pyridine or with benzoic anhydride. The properties of these compounds were very similar to those of the analogues prepared by Lawson and Searle.[1] The compounds from *N*-phenylglycine were obtained in greater yield and under milder dehydrating conditions than those from sarcosine. It had been expected that the increased potentiality of charge distribution provided by the phenyl substituent would stabilise the mesoionic compound.

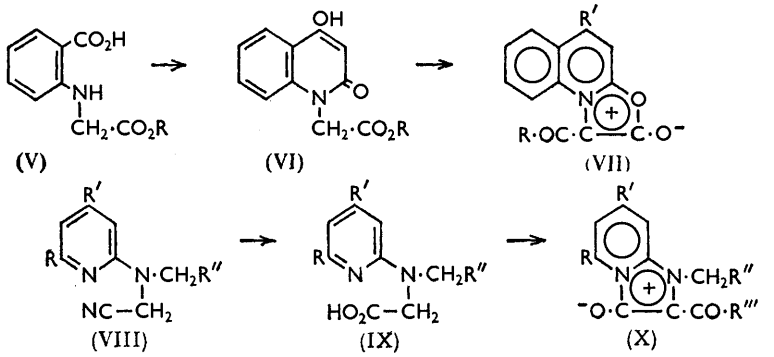
1,2-Dihydro-2-oxo-1-pyridylacetic acid [6] (III) was prepared by the action of chloroacetic acid upon 2-pyridone and elimination of hydrochloric acid by heat. With acid anhydrides it gave crystalline, neutral mesoionic compounds (IV; R = Me, Et). Hydrolysis of these with dilute acid yielded a syrup from which 2-pyridone was isolated; the compounds were also decomposed by boiling water, to carbon dioxide and an intractable syrup.

Attempts to prepare the analogous quinoline derivative (VII; R = Me, R′ = H) were unsuccessful owing to failure to obtain the intermediate acetic acid. However, the action of acetic anhydride and 3-picoline on phenylglycine-*o*-carboxylic acid (V; R = H) yielded a compound $C_{21}H_{18}O_5N_2$. This, if formulated as $C_{15}H_{11}O_5N,C_6H_7N$, would correspond to the required mesoionic compound (VII; R = Me, R′ = OAc) incorporating picoline.

[1] Lawson and Searle, *J.*, 1957, 1556.
[2] Lawson and Miles, *Chem. and Ind.*, 1958, 461.
[3] Baker and Ollis, *Quart. Rev.*, 1957, **11**, 15.
[4] Baker, *Proc. Chem. Soc.*, 1959, 75.
[5] Katritzky, *Chem. and Ind.*, 1955, 521.
[6] Kirpal, *Ber.*, 1924, **57**, 1954.

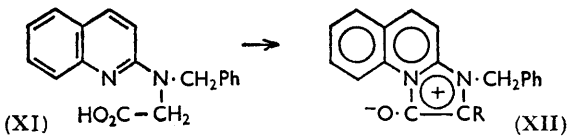
All attempts to remove picoline from the compound were unsuccessful. Treatment of phenylglycine-*o*-carboxylic acid with acetic anhydride and other tertiary amines led to charring and tar formation. Proof of the structure of this compound awaits further investigation.

Compounds of the type (X; R = H or Me, R′ = H or Me, R″ = Me or Ph, R‴ = Me or Et) were prepared by the action of acid anhydrides upon *N*-alkyl- or *N*-alkylaryl-substituted *N*-2-pyridylglycines (IX; R = H or Me, R′ = H or Me, R″ = Me or Ph). These compounds were prepared by hydrolysis of the corresponding nitriles (VIII; R = H or Me, R′ = H or Me, R″ = Me or Ph), obtained by the action of sodium hydrogen sulphite, formaldehyde, and sodium cyanide on 2-aminopyridines,[7] followed by benzylation or ethylation of the product and ring-closure. The mesoionic compounds were yellow and



crystalline, and had a green fluorescence in solution. They were unusual in being readily soluble without decomposition in hot water, from which they crystallised on cooling. Unlike compounds of type (I), they were not attacked by hot benzylamine or aniline,[1] or by hot alkali or acid. Similar compounds were obtained from 2-amino-4-methyl- and -4,6-dimethyl-pyridine.

N-Benzyl-*N*-2-quinolylglycine (XI) was produced by a route similar to that used for the pyridyl-acid. The solution obtained on hydrolysis of the corresponding nitrile possessed a yellow-green fluorescence and a small amount of benzene-soluble, neutral material was extracted from it. This was the unacylated mesoionic compound (XII; R = H) which was also obtained as a by-product of the action of acetic anhydride on the acid, the major yield being the acylated mesoionic compound (XII; R = Ac). Prolonged action of boiling dilute hydrochloric acid on the amino-acid also yielded the unacylated compound. This system, of those examined, appears to be unique in giving ring-closure under acid conditions without the need for reaction with acid anhydrides. This behaviour is doubtless associated with the facility of charge distribution in a system with such a high degree of conjugation. These mesoionic compounds of the type (II; X = N, Y = N) are reminiscent of those prepared by Bristow *et al.*[5]

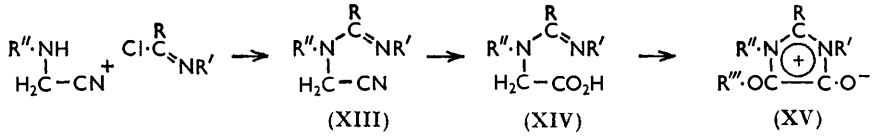


Attempts to prepare the analogous pyrimidine compounds were frustrated by the inaccessibility of *N*-2-pyrimidylglycine. In attempts to prepare this intermediate, 2-aminopyrimidine was treated with bromoacetic ester. An intense purple colour was developed, and the pigment present could be conveniently isolated by chromatography.

[7] Bristow, Charleton, Peak, and Short, *J.*, 1954, 621.

It was tinctorially strong, but light-sensitive and thus unsuitable as a dye. The structure of the compound was not elucidated.

Compounds of type (XV; R = R′ = Ph, R″ = R‴ = Me) were prepared by ring closure of *N*-(*N*-phenylbenzimidoyl)amino-acids (XIV; R = R′ = Ph, R″ = Me). *N*-Phenylbenzimidoyl chloride with methylaminoacetonitrile in the presence of triethylamine yielded *N*-methyl-*N*-(*N*-phenylbenzimidoyl)aminoacetonitrile (XIII; R = R′ = Ph, R″ = Me) from which the amino-acid was obtained by hydrolysis with hydrochloric acid. Warming this amino-acid with acid anhydrides afforded a purple fluorescence and the product was obtained as white crystals. These compounds were remarkably stable, being unreactive towards hot acids, alkalis, and benzylamine. They melted without decomposition above 200°, and crystallised from water, in which they were sparingly soluble.



(XIII) (XIV) (XV)

The ultraviolet spectra of our new mesoionic compounds were all qualitatively similar. The acetyl derivatives had somewhat higher extinction coefficients than the propionyl derivatives. Strong absorption was noted in all cases at ~2600 Å, presumably resulting from the imposition of the bathochromic shift upon the basic aromatic character of the mesoionic ring systems.

In accordance with Searle and Lawson's observations that the carbonyl group in compounds of type (I) is highly polarised, it proved impossible to prepare ketonic derivatives (such as 2,4-dinitrophenylhydrazones) from any of the compounds described. They did not form picrates or salts with mineral acids.

Experimental

N-Phenyl-N-thiobenzoylglycine Ethyl Ester.—*N*-Phenylglycine ethyl ester (10 g.) and benzoic anhydride (26 g., 2·1 mol.) were refluxed in benzene (75 ml.) for 6 hr. The solvent was removed under reduced pressure and the resultant syrup washed with sodium hydrogen carbonate solution. Repeated crystallisation from aqueous alcohol gave *N*-benzoyl-*N*-phenylglycine ethyl ester, m. p. 64° (7 g., 45%). This ester (5 g.) and phosphorus pentasulphide (5 g.) were refluxed for 2 hr. in benzene (50 ml.). The yellow filtrate was evaporated under reduced pressure and the resultant oil continuously extracted with light petroleum (b. p. 40—60°). After concentration and cooling, the material obtained was recrystallised from light petroleum to give *N-phenyl-N-thiobenzoylglycine ethyl ester* (2·25 g., 42%), yellow needles, m. p. 88—89° (Found: C, 68·2; H, 5·7. $C_{17}H_{17}O_2NS$ requires C, 68·4; H, 5·5%).

N-Phenyl-N-thiobenzoylglycine.—The above ester (1 g.) was dissolved in a solution of potassium hydroxide (0·19 g., 1 mol.) in ethanol (25 ml.) and kept for 4 days at room temperature. After removal of the solvent under reduced pressure, the resulting solid was dissolved in water, and *N-phenyl-N-thiobenzoylglycine* (0·8 g., 87%) precipitated by addition of acid. Recrystallisation from aqueous ethanol gave yellow prisms (0·7 g., 76%), m. p. 180—182° (Found: C, 66·5; H, 4·7. $C_{15}H_{13}O_2NS$ requires C, 66·4; H, 4·8%).

Ring-closure of N-*Phenyl-N-thiobenzoylglycine.*—*N*-Phenyl-*N*-thiobenzoylglycine (0·5 g.) was heated with acetic anhydride (10 ml.) for 0·5 hr. The solution rapidly darkened and the acetic anhydride was removed by evaporation under reduced pressure and by two subsequent evaporations with xylene. Two crystallisations from benzene–light petroleum (b. p. 40—60°) gave *anhydro-(4-acetyl-5-hydroxy-2,3-diphenylthiazolium hydroxide)* (0·3 g., 63·3%), yellow prisms, m. p. 170—172° (Found: C, 68·8; H, 4·2. $C_{17}H_{13}O_2NS$ requires C, 69·1; H, 4·4%), $\lambda_{max.}$ 2420, 2780 Å in ethanol (ε 7880, 9550).

Ring-closure, with C-Benzoylation, of Thiobenzoylsarcosine.—(*a*) Thiobenzoylsarcosine [1] (1 g.) was heated on the water-bath with benzoic anhydride (1·6 g., 1·5 mol.) for 2 hr., the product being dissolved in methanol and refluxed for 2 hr. All the volatile components were

evaporated at 12 mm. on the steam-bath, and the residual solid was extracted with benzene. Concentration gave *anhydro*-(4-*benzoyl*-5-*hydroxy*-3-*methyl*-2-*phenylthiazolium hydroxide*) (0·3 g.), pale yellow needles, m. p. 220—221° (Found: C, 68·7; H, 4·1; S, 10·4. $C_{17}H_{13}O_2NS$ requires C, 69·1; H, 4·4; S, 10·85%), $\lambda_{max.}$ 2400, 2460, 2550 Å in ethanol (ε 11,590, 11,180, 10,680). (*b*) To thiobenzoylsarcosine (1 g.) in pyridine (5 ml.) benzoyl chloride (4 ml.) was added slowly with cooling. The dark brown solution was warmed to 45—50° for 15 min., then evaporated under reduced pressure, and the residue washed with dilute hydrochloric acid and water. The semi-solid residue was crystallised from benzene–light petroleum (b. p. 40—60°) and then from benzene, to yield the mesoionic compound (0·5 g.), m. p. 220°.

1,2-*Dihydro*-2-*oxo*-1-*pyridylglycine*.—2-Pyridone (2 g., 1 mol.) and chloroacetic acid (2 g., 1 mol.) were dissolved in ethanol (20 ml.) and warmed to 65° for 0·5 hr. After cooling, recrystallisation from ethanol gave 1-carboxymethyl-2-hydroxypyridinium hydrochloride (3·3 g., 82·5%), felted needles, m. p. 96—98°. This salt (2 g.) was heated at 170—180° (paraffin-wax bath) for 1·5 hr., by which time evolution of hydrochloric acid was complete. An ethanolic solution of the brown solid obtained on cooling was decolorised with charcoal, and on concentration and cooling to −10°, the pyridone-acid separated as needles, m. p. 215—218° (0·8 g., 49%).

Ring-closure.—The acid (0·5 g.) was heated with acetic anhydride (5 ml.) for 2 hr. on the steam-bath. The straw-coloured solution was evaporated under reduced pressure, and traces of acetic anhydride were removed by adding, and evaporating under reduced pressure, two 10 ml. portions of xylene. The residual solid, crystallised from benzene–light petroleum (b. p. 40—60°), yielded *anhydro*-[4-*acetyl*-5-*hydroxypyridino*(2′,1′-2,3)*oxazolium hydroxide*] (IV; R = Me) (0·3 g., 51·6%), felted needles, m. p. 170—171° (Found: C, 60·9; H, 3·95; N, 7·9. $C_9H_7O_3N$ requires C, 61·0; H, 3·95; N, 7·9%), $\lambda_{max.}$ 2425, 2550, 2900, 3350 Å in ethanol (ε 19,426, 16,000, 5760, 14,300).

The homologous 4-*propionyl derivative*, m. p. 146—147·5°, silvery leaflets from benzene (55%), was obtained by treating the pyridone-acid with propionic anhydride (Found: C, 62·6; H, 4·7; N, 7·0. $C_{10}H_9O_3N$ requires C, 62·8; H, 4·7; N, 7·3%), $\lambda_{max.}$ 2425, 2550, 2900, 3350 Å in ethanol (ε 13,820, 10,470, 3035, 10,180).

Reactions.—(*a*) The compound (IV; R = Me) (0·1 g.) in boiling water evolved carbon dioxide (approx. 0·5 mol.). Evaporation under reduced pressure then yielded a tar. (*b*) The compound (0·1 g.) was refluxed in benzylamine (5 ml.) for 1 hr. Addition of ligroin to the cooled solution precipitated a yellow oil which solidified on scratching. Crystallisation from benzene–light petroleum (b. p. 40—60°) and then from acetone gave felted needles (0·1 g.), m. p. 199—200° (Found: C, 69·0; H, 5·6; N, 11·5. $C_{14}H_{14}O_2N_2$ requires C, 69·0; H, 5·8; N, 11·5%).

Ring-closure of Phenylglycine-o-carboxylic Acid.—To phenylglycine-*o*-carboxylic acid (5 g.) in acetic anhydride (40 ml.), picoline (10 ml.) was added cautiously and with cooling. The dark brown solution, after 1 hr. at room temperature, was refluxed for 1·5 hr. The volatile components were removed under reduced pressure and the resultant tar extracted with light petroleum (b. p. 60—80°). On decolorisation with charcoal and concentration, long colourless needles, m. p. 80—83°, separated (0·9 g.) (Found: C, 66·7; H, 4·8; N, 7·0. $C_{15}H_{11}O_5N,C_6H_7N$ requires C, 66·7; H, 4·8; N, 7·0%). Refluxing this material with water or dilute hydrochloric acid gave unresolvable tars, while small quantities of carbon dioxide were evolved. No evidence of the liberation of picoline was obtained.

Ring-closure of N-*Benzyl*-N-2-*pyridylglycine*.—*N*-Benzyl-*N*-2-pyridylaminoacetonitrile [5] (9 g.) was heated with 5N-hydrochloric acid (50 ml.) for 1 hr. The solution was made alkaline with 3N-sodium hydroxide and evaporated to dryness under reduced pressure. The residue was extracted with ethanol, ether was added, and the solution kept at −10° for 24 hr.; sodium *N*-benzyl-*N*-2-pyridylglycine, m. p. 300—301°, crystallised (6·5 g., 58%).

Sodium *N*-benzyl-*N*-2-pyridylglycine (5 g.) was heated on the water-bath with acetic anhydride (50 ml.) for 1 hr. The solution rapidly became yellow with a slight green fluorescence and eventually became dark green. Evaporation under reduced pressure and then twice more with 10 ml. portions of xylene gave an oil which was extracted with benzene and decolorised with charcoal. Concentration of the solution and addition of light petroleum (b. p. 40—60°) provided *anhydro*-[4-*acetyl*-3-*benzyl*-5-*hydroxypyridino*(1′,2′-1,2)*imidazolium hydroxide*] (X; R = R′ = H, R″ = Ph, R‴ = Me), yellow needles, m. p. 170—171° (3·5 g.) (Found: C, 72·1; H, 5·3. $C_{16}H_{14}O_2N_2$ requires C, 72·1; H, 5·3%), $\lambda_{max.}$ 2620 Å in ethanol (ε 15,045).

N-Benzyl-*N*-2-pyridylglycine with propionic anhydride similarly gave the *propionyl analogue*,

yellow needles (80%), m. p. 116—117°, $\lambda_{max.}$ 2620 Å in ethanol (ε 14,950) (Found: C, 72·5; H, 5·7. $C_{17}H_{16}O_2N_2$ requires C, 72·9; H, 5·7%).

Ring-closure of N-*Ethyl*-N-2-*pyridylglycine*.—*N*-Ethyl-*N*-2-pyridylaminoacetonitrile was hydrolysed as in the case of the benzyl derivative. The amino-acid and the sodium salt proved difficult to crystallise and the residue, obtained by evaporation under reduced pressure, of the basified hydrolysate, was treated directly with acetic anhydride. *Anhydro*-[4-*acetyl*-3-*ethyl*-5-*hydroxypyridino*(1′,2′-1,2)*imidazolium hydroxide*] (X; R = R′ = H, R″ = R‴ = Me), m. p. 195—197°, crystallised from benzene as yellow prisms (49%) (Found: C, 64·6; H, 6·0; N, 14·0. $C_{11}H_{12}O_2N_2$ requires C, 64·6; H, 5·9; N, 13·7%), $\lambda_{max.}$ 2620, 4000 Å in ethanol (ε 13,810, 9085).

A *propionyl homologue*, obtained by treating the amino-acid with propionic anhydride, crystallised as yellow prisms (61%), m. p. 150—151° (Found: C, 65·8; H, 6·5. $C_{12}H_{14}O_2N_2$ requires C, 66·0; H, 6·4%).

The 4-*benzoyl homologue*, yellow prisms (from benzene), m. p. 185° (40%), was similarly prepared by the action of benzoyl chloride–pyridine on the amino-acid (Found: C, 71·8; H, 5·55. $C_{16}H_{14}O_2N_2$ requires C, 72·1; H, 5·3%).

N-*Benzyl*-N-(4-*methyl*-2-*pyridyl*)*glycine*.—*N*-(4-Methyl-2-pyridyl)aminoacetonitrile was prepared by a modification of the method of Bristow *et al.*[7] 40% Aqueous formaldehyde (10·5 ml.) and 38% sodium hydrogen sulphite solution (27·2 ml., 1·5 mol.) were mixed and heated to 95° for 0·5 hr. 2-Amino-4-methylpyridine (14·1 g.), in 50% aqueous alcohol (100 ml.), was added to the mixture and the whole was refluxed with stirring for 2 hr. The solution was cooled and sodium cyanide (13·1 g.) in water (26 ml.) added slowly, an exothermic reaction resulting. The solution was refluxed with stirring for 20 hr. and the solvents were evaporated under reduced pressure. The solid was extracted with chloroform (500 ml.), and the volume of the extract reduced to 50 ml. On cooling, the product separated as brown nodules. Recrystallisation from ethyl acetate gave N-(4-*methyl*-2-*pyridyl*)*aminoacetonitrile*, prisms (12·1 g., 88·8%), m. p. 116—117° (Found: C, 65·0; H, 6·1. $C_8H_9N_3$ requires C, 65·3; H, 6·1%).

This nitrile (5 g.) in benzene (50 ml.) was refluxed with benzyl chloride (10 ml.) for 15 min. On cooling, the N-*benzyl*-N-(4-*methyl*-2-*pyridyl*)*aminoacetonitrile hydrochloride* separated; it recrystallised from ethanol as prisms (4·3 g., 53%), m. p. 265° (decomp.) (Found: C, 65·9; H, 6·1. $C_{15}H_{15}N_3$,HCl requires C, 66·0; H, 6·1%).

The hydrochloride (3 g.) was hydrolysed to the acid as in the case of *N*-benzyl-*N*-2-pyridylglycine. The sodium salt of the amino-acid did not crystallise from the ethanolic solution and was precipitated with dry ether as an amorphous solid (3 g.), m. p. 270—280°.

Ring-closure of N-*Benzyl*-N-(4-*methyl*-2-*pyridyl*)*glycine*.—The sodium salt (1·5 g.) was heated with acetic anhydride (10 ml.) on the water-bath for 0·5 hr., then treated as above. Crystallisation from benzene gave *anhydro*-[4-*acetyl*-3-*benzyl*-5-*hydroxy*-4′-*methylpyridino*-(1′,2′-1,2)*imidazolium hydroxide*], yellow prisms exhibiting a yellow-green fluorescence in solution (1·1 g., 67%) (Found: C, 73·0; H, 5·6. $C_{17}H_{16}O_2N_2$ requires C, 72·9; H, 5·7%).

Ring-closure of N-*Ethyl*-N-(4-*methyl*-2-*pyridyl*)*glycine*.—*N*-(4-Methyl-2-pyridyl)aminoacetonitrile (5 g.) was warmed for 0·5 hr. with ethyl iodide (5 g.) in dry benzene (20 ml.), the product separating on cooling as pale yellow prisms. Recrystallisation from ethanol gave *N*-ethyl-*N*-(4-methyl-2-pyridyl)aminoacetonitrile hydriodide (4·9 g., 48·2%), m. p. 185° (Found: C, 39·7; H, 4·6. $C_9H_{11}N_3$,HI requires C, 39·6; H, 4·6%).

Hydrolysis, as previously, gave an uncrystallisable product, which, warmed with acetic anhydride on the water bath for 0·5 hr., gave *anhydro*-[4-*acetyl*-3-*ethyl*-5-*hydroxy*-4′-*methylpyridino*(1′,2′-1,2)-*imidazolium hydroxide*], yellow prisms (from benzene) (42%), m. p. 209° (Found: C, 66·6; H, 6·35. $C_{12}H_{14}O_2N_2$ requires C, 66·2; H, 6·4%).

Ring-closure of N-*Benzyl*-N-(4,6-*dimethyl*-2-*pyridyl*)*glycine*.—The nitrile, prepared as above, crystallised from chloroform–light petroleum (b. p. 40—60°) as prisms (97%), m. p. 92° (Found: C, 67·2; H, 7·0. $C_9H_{11}N_3$ requires C, 67·1; H, 6·8%). The *benzyl derivative hydrochloride*, prepared as above, crystallised from ethanol–ether as prisms (41·4%), m. p. 238—240° (Found: C, 66·2; H, 6·0. $C_{16}H_{17}N_3$,HCl requires C, 66·6; H, 6·25%).

Hydrolysis was effected as previously and the acid hydrolysate made alkaline with sodium hydroxide and evaporated to dryness. The residue on treatment with acetic anhydride on the steam-bath developed a red-green fluorescence, assuming in 2 hours a blue-brown colour. The solution, processed as previously, gave *anhydro*-[4-*acetyl*-3-*benzyl*-5-*hydroxy*-4′,6′-*dimethylpyridino*(1′,2′-1,2)*imidazolium hydroxide*] (X; R = R′ = R‴ = Me, R″ = Ph), yellow prisms (from aqueous ethanol), exhibiting a green fluorescence in solution (43%, based on nitrile),

m. p. 170·5° (Found: C, 73·2; H, 6·3. $C_{18}H_{18}O_2N_2$ requires C, 73·5; H, 6·1%), $\lambda_{max.}$ 2650, 4000 Å in ethanol (ε 11,685, 7855).

N-*Benzyl*-N-2-*quinolylglycine* (XI).—N-2-*Quinolylaminoacetonitrile* was prepared as was the pyridyl-nitrile, crystallising from chloroform as brownish monoclinic prisms (49%), m. p. 188—191° (Found: C, 71·9; H, 5·05. $C_{11}H_9N_3$ requires C, 72·1; H, 4·9%). It (3 g.) was refluxed in benzyl chloride (10 ml.) for 48 hr., and the mixture poured into ether (100 ml.). The resultant brown solid was dissolved in ethanol (20 ml.), and the solution made just acid to Congo Red by the addition of concentrated sulphuric acid. In 24 hr. at −10°, N-*benzyl*-N-2-*quinolylaminoacetonitrile hydrogen sulphate* separated as prisms (3·7 g., 63·3%), m. p. 300° (decomp.) (from aqueous ethanol) (Found: C, 58·4; H, 4·5. $C_{18}H_{16}O_4N_3S$ requires C, 58·3; H, 4·3%).

This sulphate (3 g.) was refluxed for 4 hr. with 5N-hydrochloric acid (20 ml.). Considerable darkening occurred. When the brown oil which separated on cooling was washed with a large quantity of cold water it solidified. The solid crystallised from benzene–light petroleum (b. p. 40—60°), giving yellow needles (0·7 g.), m. p. 100° (after decomposing at 65°) (Found: C, 78·5; H, 5·5. $C_{18}H_{14}ON_2$ requires C, 78·7; H, 5·1%). $\lambda_{max.}$ 2210, 2780, 2850 Å in ethanol (ε 25,240, 12,162, 13,162). This substance corresponds to the unacetylated mesoionic *compound* (XII; R = H).

The residual acid hydrolysate was brought to pH 7 with saturated sodium hydrogen carbonate solution, a white solid separating. Crystallisation from ethanol gave the required *acid* (XI) (2·1 g., 54·6%) as prisms, m. p. 195—196° (Found: C, 73·9; H, 5·53. $C_{18}H_{16}O_2N_2$ requires C, 73·9; H, 5·5%).

Ring-closure. This acid was heated on the water-bath with acetic anhydride (10 ml.) for 2 hr. and worked up as previously. The benzene solution on concentration and cooling gave *anhydro-*[*4-acetyl-3-benzyl-5-hydroxyquinolino*(1′,2′-1,2)*imidazolium hydroxide*], yellow prisms, m. p. 113—115° (0·7 g., 43%) (Found: C, 76·2; H, 5·3. $C_{20}H_{16}O_2N_2$ requires C, 76·0; H, 5·1%). Further concentration and cooling gave yellow needles (0·2 g., 12·3%) identical with the neutral product of the hydrolysate above.

N-Benzyl-*N*-2-quinolylglycine (1·0 g.) was refluxed for 24 hr. with 3N-hydrochloric acid (10 ml.). The dark solution was evaporated to dryness under reduced pressure and the solid residue extracted with benzene. Concentration and cooling yielded anhydro-[3-benzyl-5-hydroxyquinolino(1′,2′-1,2)imidazolium hydroxide] (XII; R = H) (0·13 g., 12%).

Attempts to Prepare N-2-*Pyrimidylglycine.*—Attempts to cyanomethylate the amino-group of 2-aminopyrimidine failed. Accordingly the reactions with chloroacetic acid and bromoacetic ester were examined.

(a) *Chloroacetic acid.* 2-Aminopyrimidine (2 g.) and chloroacetic acid (2 g.) were warmed on the water-bath for 0·5 hr. An intense purple colour developed. The mixture was evaporated to dryness under reduced pressure and the residue dissolved in ethanol (15 ml.). The solution was passed through a kieselguhr column (24″ × 1″), the purple pigment being strongly retained. Evaporation of the colourless ethanol passing through yielded 2-aminopyrimidine chloroacetate (3 g.), m. p. 91—93°. Elution of the column with 50% aqueous acetone and removal of the solvent gave hygroscopic crystals which could not be purified by recrystallisation. They were soluble in water and very soluble in sodium carbonate solution, developing a purple-red colour. The purple colour was regenerated by addition of acid. When 2-aminopyrimidine chloroacetate was heated to 240° for 1 hr., the purple compound was formed.

(b) *Bromoacetic ester.* 2-Aminopyrimidine (10 g.) and ethyl bromoacetate (5 ml.) were warmed together on the water-bath for 0·5 hr. The deep purple colour developed as previously and removal of the volatile components under reduced pressure and crystallisation from alcohol gave 2-aminopyrimidine hydrobromide (0·7 g.). The mother-liquor was passed through a kieselguhr column which retained the pigment. Elution with 50% aqueous ethanol and evaporation gave a solid which crystallised from methanol at −10° as black crystals with a golden sheen, m. p. >360°. This material was soluble in water and ethanol with a purple-blue colour and in sodium carbonate solution with a purple-red colour. Evaporation of the latter solution to dryness under reduced pressure provided a residue which was insoluble in ethanol. The original pigment (Found: C, 35·3; H, 4·4; N, 16·6%) was absorbed from aqueous solution by both base- and acid-ion exchange resins. The aqueous solution was bleached by concentrated nitric acid, the colour being regenerated on dilution. Addition of mercuric chloride to an aqueous solution precipitated an insoluble derivative. A similar pigment was obtained

from 2-methylaminopyrimidine. No corresponding colour was obtained when 2-amino-4-methylpyrimidine, guanine, or adenine was used as the amine.

N-*Methyl*-N-(N-*phenylbenzimidoyl*)*aminoacetonitrile*.—A mixture of benzanilide (20 g.) and thionyl chloride (30 ml.) was refluxed for 0·5 hr., the residual thionyl chloride being then evaporated under reduced pressure at 50° and the syrup remaining dissolved in light petroleum (b. p. 40—60°). The solution was freed from a small residual portion of benzanilide (0·3 g.) and evaporated to dryness on the steam-bath. The resulting oily *N*-phenylbenzimidoyl chloride solidified as a brown solid, m. p. 40° (19 g., 87%), and was sufficiently pure for the subsequent reaction.

N-Phenylbenzimidoyl chloride (10 g.) was dissolved in triethylamine twice redistilled from " Hi-drite " (20 ml.), the temperature being kept at 0°. Methylaminoacetonitrile (3·3 g.) was added slowly to the cooled mixture and stirring continued for 0·25 hr. The volatile components of the reaction were removed under reduced pressure at 60°, the solid residue was dissolved in hydrochloric acid, and the solution was filtered. The filtrate was made strongly alkaline with 3N-sodium hydroxide, and the separating oil extracted with ether which on evaporation yielded a solid. This was extracted with light petroleum (b. p. 60—80°) and on concentration yielded N-*methyl*-N-(N-*phenylbenzimidoyl*)*aminoacetonitrile* as monoclinic prisms, m. p. 106—107° (7 g., 65·5%) (Found: C, 77·0; H, 5·75; N, 16·8. $C_{16}H_{15}N_3$ requires C, 77·1; H, 6·0; N, 16·8%).

Ring-closure. The nitrile (5 g.) was refluxed with 2% hydrochloric acid (50 ml.) for 0·75 hr., then evaporated to dryness. Addition of excess of saturated aqueous sodium hydrogen carbonate dissolved all but a small amount of solid (which was filtered off). The filtrate, evaporated to dryness, gave a solid residue which gave a positive ninhydrin test. Acetic anhydride (25 ml.) was added, and the solution heated on the steam-bath for 1·5 hr., becoming dark brown immediately and developing a deep purple fluorescence. After cooling and filtration the acetic anhydride was evaporated under reduced pressure and final traces were removed by two evaporations with xylene. The residue was dissolved in benzene and decolorised with charcoal to give on concentration *anhydro*-[4-*acetyl*-3-*methyl*-5-*hydroxy*-1,2-*diphenylimidazolium hydroxide*] (XV; R = R′ = Ph, R″ = R‴ = Me), colourless plates, m. p. 243—244° (3 g., 55%) (Found: C, 74·2; H, 5·4. $C_{18}H_{16}O_2N_2$ requires C, 74·0; H, 5·5%), $\lambda_{max.}$ 2600, 3200, 3280 Å in ethanol (ε 8550, 16,150, 15,620).

A homologous *compound* was obtained in an identical manner by treating the amino-acid with propionic anhydride; this formed plates, m. p. 215°, from benzene (49%) (Found: C, 74·5; H, 5·9; N, 9·2. $C_{19}H_{18}O_2N_2$ requires C, 74·5; H, 5·9; N, 9·15%), $\lambda_{max.}$ 2660, 3200, 3280 Å in ethanol (ε 8220, 15,305, 14,805). Neither of these compounds was attacked by boiling benzylamine or warm dilute acid and alkali. They crystallised from a large quantity of water.

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