Structure Elucidation, Regioselective Alkylation, and Ring-Opening of 2-Phenyl-3*H*-pyridazino[6,1-*b*]quinazoline-3,10(5*H*)-dione

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Dedicated to Professor Gurnos Jones on the occasion of his 70th birthday

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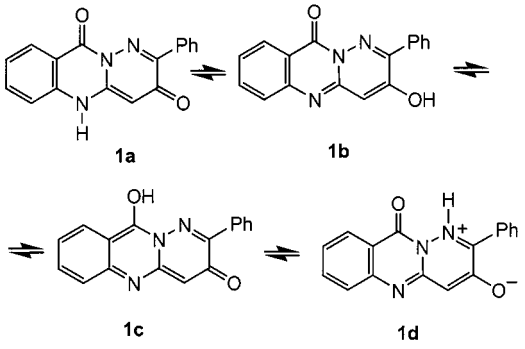
Structure elucidation of 2-phenyl-3*H*-pyridazino[6,1-*b*]quinazoline-3,10(5*H*)-dione (**1**) revealed that it exists in one of the four possible tautomeric structures (i.e. **1a**). Although this tautomeric form has two different carbonyl groups, only one of these can be detected in the IR and Raman spectra. X-ray investigation led to the conclusion that this abnormal spectral behaviour is due to a special orientation of the molecules in the unit cell. Alkylation of **1** in the presence of a base in an organic solvent under anhydrous conditions afforded an *O*-alkyl derivative as the main product accompanied by a small amount of the 5-*N*-alkyl derivative, whereas under aqueous basic conditions a hydrolytic ring-opening took place to afford a new zwitterion as the main product.

Introduction

We have recently reported an easy synthetic path to the title compound **1**[1] and, although this derivative can exist in the different tautomeric forms **1a**−**d**, structure **1a** was anticipated on the basis of a major difference between its UV spectrum and that of the 3-methoxy derivative **2** synthesized by an independent method.[2]

Since this structural assignment was based purely on an indirect conclusion, a thorough re-investigation of the structure of **1** was deemed necessary. Thus, in addition to the UV spectrum of this compound, its IR and Raman spectra have also been recorded and evaluated.



Results and Discussion

In contrast to our expectations, only one carbonyl band was observed in both the IR and Raman spectra, supporting the presence of **1b**−**d** rather than **1a**. As the carbonyl absorption and the corresponding Raman scattering of the solid sample appeared at fairly different wavenumbers [1734 cm^{-1} in IR (KBr) and 1719 cm^{-1} in the Raman], dimeric structure **1e** had to be considered as a further possibility. In this case, the band at 1734 cm^{-1} could be assigned to the asymmetrically coupled ν(C10=O) vibrations and the Raman scattering at 1719 cm^{-1} to their symmetric counterpart. This assumption seemed to be in accordance with the appearance of a broad diffuse ν(NH) absorption in the range 3200−2500 cm^{-1}, indicating the presence of a strong hydrogen bond.

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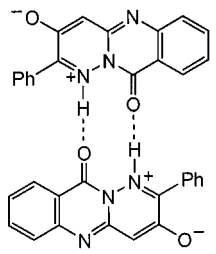


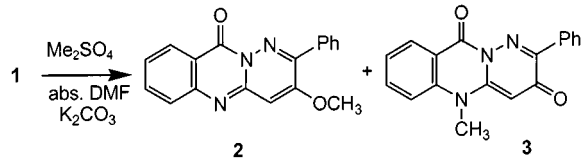
1e

However, this hypothesis could be ruled out upon investigation of the IR and Raman spectra of **1** in solution (DMSO); in the IR spectrum, the C=O band underwent a low frequency shift (to 1724 cm^{-1}), whereas in the Raman spectrum the corresponding band was shifted in the opposite direction (to 1723 cm^{-1}). This peculiar behaviour of the carbonyl absorption may be due to a special orientation of these groups in the unit cell that allows coupling between their vibrations.

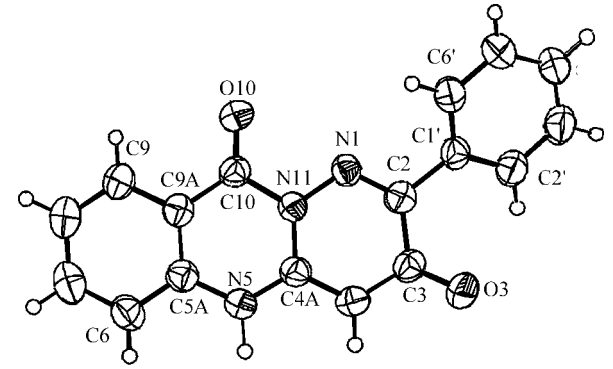
All these considerations indicated that no clear decision could be made in favour of either of the possible tautomeric structures **1a**−**e** on the basis of the spectroscopic evidence, and thus further synthetic investigations seemed necessary.

Alkylation of the conjugate anion of **1** seemed of particular interest; this anion could, in principle, be transformed to four different (i.e. to 1-*N*-, 3-*O*-, 5-*N*-, and 10-*O*-alkylated) products, which can be considered as "fixed forms" of the tautomers **1a**−**d**. If one or two of these alkylated products could be obtained, comparison of their UV spectra with that of **1** could provide effective support for the existence of one of the tautomeric forms. Extensive literature[3−6] is available concerning the alkylation of multifunctional anions such as pyridinones,[3] pyridine-fused zwitterions,[4] and other related azinones and azolones.[5,6] These studies reveal that the outcome of such reactions (i.e. whether *N*- or *O*-alkylation predominates) may sensitively depend on the nature of the reagent and reaction conditions.

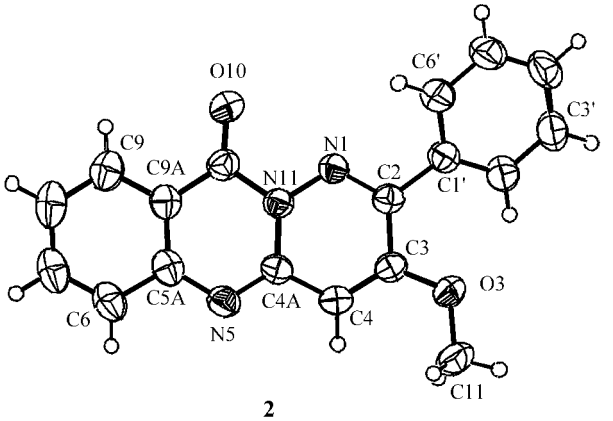
Thus, **1** was alkylated under anhydrous conditions (in DMF in the presence of potassium carbonate) to give a mixture of two products (in a ratio of 7:3). The major product proved to be the 3-methoxy derivative **2** (found to be identical to a previously obtained sample[2]), whereas ^1H NMR analysis of the minor product (NOE between the methyl proton and the two aromatic protons in *peri* positions) showed it to be the *N*-methyl derivative **3**.



This result opened a novel approach for the structure elucidation of the key compound **1**. The new methyl derivative **3** features the same chromophore as tautomer **1a** and thus, if our original structure assignment is correct and the tautomeric structure **1a** does indeed exist, comparison of its UV spectrum with that of **1** should provide additional evidence in favour of our previous suggestion. We found the relevant UV spectra to be nearly identical, which seemed to support our original structural hypothesis. However, this conclusion seemed contradictory to the IR and Raman spectral analyses, which had apparently ruled out the presence of structure **1a**. Due to this controversy, X-ray analyses of **1**, **2**, and **3** were carried out. The results are depicted in Figure 1.



1



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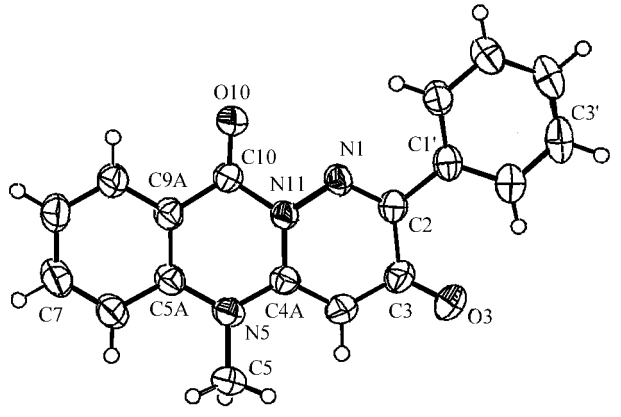


3

Figure 1. Molecular diagrams of **1**, **2**, and **3** showing the numbering of atoms; atomic displacement parameters are represented at a 50% probability level

For compound **1**, the result unambiguously established the presence of structure **1a** in the solid state. An intermolecular N5−H5···O3 ($-x + 1/2$, $y - 1/2$, $-z + 1/2$) hydrogen bond is formed [N5−H5: 1.01 Å; H5···O3: 1.70 Å; N5···O3: 2.701(1) Å; N5−H5···O3: 167.0°]. The C3−O3 bond is elongated [1.251(1) Å], which may be attributed to the strong N5−H5···O3 hydrogen bond. The C10−O10 bond length is much shorter, which is in accordance with the disappearance of the second carbonyl band (i.e. C3=O) in the IR and Raman spectra.

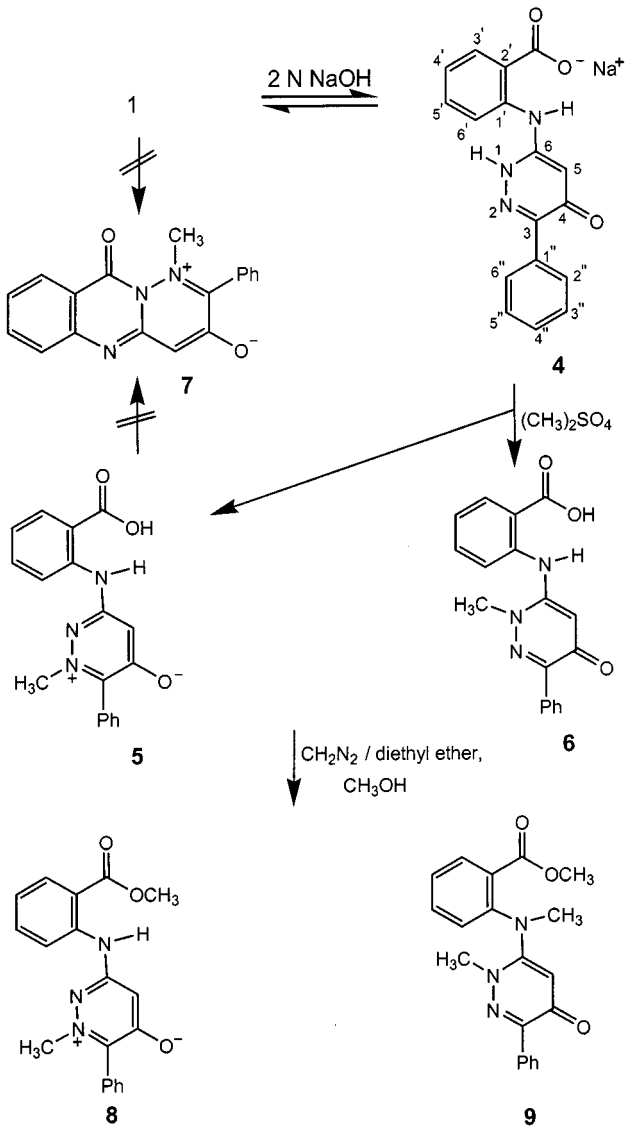
Comparison of the structures of **1**, **2**, and **3** reveals that the substitution at N5 in the central ring results in a variation in the endocyclic bond angles. While the C9a−C10−N11 angle lies in the range 113.0−114.5°, the angle at N5 is 117.3(1)° in the unsubstituted molecule **2** and 123.7(1)° and 121.9(1)° in **1** and **3**, respectively. The opposite trend is observed for the N5−C4a−N11 angles [**1**: 118.0(1)°; **2**: 123.9(1)°; **3**: 118.3(1)°], while the sum of the endocyclic angles is 720° in all the molecules. The explanation for this may be similar to that described as "lone pair induced" alteration of bond angles observed[7] for 1,2,4-triazoles, i.e. the high spatial requirement of the lone pair makes the endocyclic bond angle smaller.

The pyridazinoquinazoline skeletons are essentially planar, although slightly folded along the C10···N5 axis when N5 is substituted [**1**: 3.9(5)°; **2**: 1.2(4)°; **3**: 6.2(4)°]. The phenyl ring lies in the main molecular plane in **3**, but forms dihedral angles of 35.9(5)° and 27.3(6)° [4.2(3)° in **3**] with the pyridazinoquinazoline moiety in **1** and **2**, respectively.

As a continuation of the alkylation experiments, the methylation of **1** was also carried out in aqueous base. In order to obtain an aqueous solution, the starting compound **1** was added to 2 N sodium hydroxide solution and the resulting suspension was heated to 60 °C for 30 min, whereupon a clear solution was gradually formed. Interestingly, we observed that during this procedure a significant colour change took place; the mixture first became yellow and then became colourless again. The basic solution was treated with dimethyl sulfate and the reaction was found to be complete within 2 d.

As the colour change seen during the formation of the reactant solution was unexpected, we first checked whether any major structural change of **1** had occurred under the aqueous conditions (e.g. a hydrolytic ring-opening, as is well known for related nitrogen heterocycles[8−10]).

Thus, an aliquot of the basic solution − prior to addition of the methylating agent − was investigated by ^{1}H and ^{13}C NMR. Significant changes were found; a new series of peaks appeared in both spectra, e.g. a strong downfield shift of the signal of C10 in **1** (δ = 156.0) to the position of that of the respective carbon atom (i.e. that in the carboxylic group) in **4** (δ = 173.0) and a significant upfield shift of the 4-H signal in **1** (δ = 6.70) to the position of that of the same proton in **4** (i.e. 5-H, δ = 6.00) was observed, which revealed that a hydrolytic ring-opening had occurred to give the salt **4**. The open-chain species **4** was found to be in equilibrium with **1**, as shown by the reversible change in the relative intensities of the two series of peaks upon changing the temperature. In accordance with this equilibrium, the salt **4** could not be isolated as a pure solid substance as acidification yielded the starting compound **1** containing **4** only as an impurity.



Work-up of the reaction mixture following methylation of **1** in sodium hydroxide solution afforded a mixture of two products, which could not be separated. Its ^{1}H NMR analysis revealed that the two products were present in a ratio of ca. 4:1. A key feature of the spectrum of the main product was that the protons of the methyl group introduced during the reaction were seen to be in the vicinity of the phenylpyridazine phenyl group (NOE) and thus both **5** and **7** could be regarded as possible structures. Due to the apparent presence of an NH proton, however, the ring-closed structure **7** could be ruled out (contrary to our earlier suggestion in a preliminary paper on this subject[1]), thus pointing to ring-opening and the subsequent formation of the zwitterionic **5**.

The ^{1}H NMR spectrum of the product mixture also allowed conclusions to be drawn concerning the minor com-

ponent; the methyl proton signal in this case did not show any NOE effect with the pyridazine−phenyl group, but a significant HETCOR was found between these protons and the carbon atom adjacent to the nitrogen atom bearing the methyl group. These findings strongly suggested that the minor product had structure **6**.

An interesting possibility for formation of the hypothetical tricyclic zwitterionic structure **7** could be a cyclocondensation ring-closure of **5** similar to the ring-closure of **4** to **1** found to be in fast equilibrium in acid. However, our efforts to perform this cyclization failed and even heating of **5** in trifluoroacetic acid led to only decomposition.

A final proof of structures **5** and **6** was obtained by methylation of a mixture of these using diazomethane; this led to two products (**8** and **9**), which were isolated by chromatography. Analysis of the pure compounds unambiguously confirmed our structural assignment; the methyl ester **8** was formed by a simple esterification of the main product **5**, whereas in the case of the minor product **6** formation of the ester function was also accompanied by methylation of the anilino nitrogen atom to afford compound **9**.

These results showed that the alkylation reaction proceeded in a fairly selective manner. Two features of this reactions should be emphasized:

(a) Methylation of **1** under anhydrous conditions gave only **2** and **3**; no **7** was formed, nor was the oxygen atom of the pyrimidine ring alkylated. In other words, only one region of the molecule (C3−O and N5) proved to be reactive in these transformations, whereas C10−O and N1 were unreactive.

(b) Most interestingly, alkylation of the ring-opened anilinopyridazine **4** furnished the zwitterion **5** as the main product, and besides the observed side reaction (i.e. methylation of the other ring-N atom), neither the pyridazine oxygen atom nor the aniline nitrogen atom participated in these transformations.

From our earlier theoretical studies,[11] it was concluded that the regioselectivities of reactions of planar heteroaromatic compounds were in good agreement with molecular electrostatic potential maps; generally, methylation occurs at those sites of the molecule having the most negative electrostatic values. In order to rationalize the experimental findings described herein, an MEP map was calculated[11] for the reactive form of **1** (i.e. for its conjugate anion). The result is depicted in Figure 2.

Inspection of this electrostatic potential map shows that, for the anion of **1**, the most negative potential value can be found in the vicinity of O3, followed by the value at N5, whereas the potential values at the heteroatoms on the "upper" side of the molecule (i.e. at N1 and C10−O) are negligible. This is in nice agreement with our experimental finding; only O3 and N5 were found to undergo alkylation (3-MeO compound **2** was formed as the main product, accompanied by a minor amount of 5-Me compound **3**), whereas the other region of the molecule proved to be unreactive.

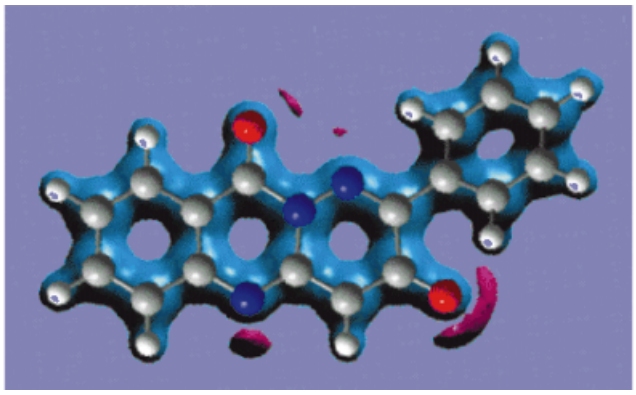


Figure 2. MEP map of the conjugate anion of **1** calculated by using the Gaussian program; hydrogen atoms: white, carbon atoms: grey, nitrogen atoms: blue, oxygen atoms: red; the areas of the red spots in the vicinities of the heteroatoms are proportional to the values of their electrostatic potentials

Conclusion

The observed ring-opening reaction of this easily accessible new heteroaromatic ring system would seem to open the way to a series of novel interesting pyridazine structures. Furthermore, theoretical calculations reveal that our previously suggested tool for prediction of the site of alkylation of planar heteroaromatics can be effectively applied to interpret the experimental findings.

Experimental Section

General: Melting points [°C] were determined with a Büchi apparatus and are uncorrected. IR and Raman spectra were recorded with a Nicolet Magna 750 FT-IR and a Nicolet FT-Raman spectrometer, respectively. NMR spectra were recorded with a Varian UNITY INOVA spectrometer (400 MHz for ^{1}H, 100 MHz for ^{13}C).

Alkylation of 2-Phenyl-3*H*-pyridazino[6,1-*b*]quinazoline-3,10(5*H*)-dione (1) in DMF: To a mixture of **1** (0.196 g, 0.68 mmol), dimethyl formamide (5 mL), and anhydrous potassium carbonate (200 mg), dimethyl sulfate (0.1 mL) was added dropwise under argon. The reaction mixture was stirred at 60 °C for 2 h, then a second portion of dimethyl sulfate (0.1 mL) was added, and the heating and stirring were continued for a further 2 h. The reaction mixture was subsequently poured onto ice/water and the product was extracted with chloroform. Chromatography on silica using chloroform as the eluent yielded two products in a ratio of ca. 7:3.

3-Methoxy-2-phenyl-10*H*-pyridazino[6,1-*b*]quinazolin-10-one (2): Yield: 0.135 g (66%), m.p. 237−240 °C (acetonitrile). All spectroscopic and analytical data of this product proved to be identical to those of the authentic sample obtained previously by a different procedure.[2]

5-Methyl-2-phenyl-3*H*-pyridazino[6,1-*b*]quinazoline-3,10(5*H*)-dione (3): Yield: 0.059 g (0.195 mmol, 28%), m.p. 251−253 °C (dimethylformamide). ^{1}H NMR ([D$_6$]DMSO): δ = 3.68 (s, 3 H, CH$_3$), 6.49 (s, 1 H, 4-H), 7.42 (t, *J* = 8.0 Hz, 1 H, 8-H), 7.50−7.56 (m, 3 H, 3′-,4′-,5′-H), 7.72 (d, *J* = 8.0 Hz, 1 H, 6-H), 7.92 (td, 1 H, *J* = 8.0, 1.5 Hz, 7-H), 8.12−8.17 (m, 2 H, 2′-,6′-H), 8.25 (dd, *J* = 8.0, 1.6 Hz, 1 H, 9-H). ^{13}C NMR ([D$_6$]DMSO): δ = 34.0, 98.1, 115.5, 123.3, 127.9, 128.6, 129.2, 130.0, 133.1, 136.4, 140.8, 148.8, 155.8,

169.5, 176.8. UV (CH_3CN): λ = 216, 246, 270, 298, 376 nm. IR (KBr): $\tilde{\nu}$ = 1719, 1621, 1578, 1522, 1382, 1241 cm^{-1}.

Detection of the Ring-Opening of 1 To Give the Sodium Salt 4: To a solution of **1** (30 mg) in [D_6]DMSO (0.5 mL) was added a 2 N solution of NaOD in D_2O (0.1 mL). The resulting mixture was heated at 60 °C for 30 min and then allowed to stand at room temperature overnight. The ^1H and ^{13}C NMR spectra revealed the presence of **4**. ^1H NMR ([D_6]DMSO + NaOD): δ = 6.00 (s, 1 H, 5-H), 6.70 (m, 1 H, 4′-H), 7.22 (m, 1 H, 5′-H), 7.23−7.30 (m, 3 H, 3′′-,4′′-,5′′-H), 7.91 (dd, *J* = 8.0, 1.5 Hz, 1 H, 3′-H), 8.11 (dd, *J* = 8.0, 1.5 Hz, 1 H, 6′-H), 8.12 (m, 2 H, 2′′-,6′′-H). ^{13}C NMR ([D_6]DMSO + NaOD): δ = 102.0 (C-5), 117.1 (C-6′), 118.0 (C-4′), 123.4 (C-2′), 127.1 (C-4′′), 127.9 (C-3′′,5′′), 128.8 (C-2′′,6′′), 130.9 (C-5′), 132.2 (C-3′), 139.3 (C-1′′), 144.6 (C-1′), 151.4 (C-3),158.1 (C-6), 168.1 (C-4), 173.0 (COONa).

Alkylation of 2-Phenyl-3*H*-pyridazino[6,1-*b*]quinazoline-3,10(5*H*)-dione (1) in Aqueous Sodium Hydroxide Solution (Formation of a Mixture of 5 and 6): A suspension of **1** in 2 N aqueous sodium hydroxide solution (25 mL) was heated at 60 °C for 30 min to yield a clear solution. This solution was then cooled to room temperature, dimethyl sulfate (0.7 mL) was added, and the resulting mixture was stirred at this temperature until the starting material had been consumed (TLC monitoring, ca. 2 d). The reaction mixture was then adjusted to pH = 4 by the addition of hydrochloric acid and the precipitate formed was collected by filtration and dried. Because of the poor solubility of this solid, no purification could be carried out. Analysis of the NMR spectra (^1H and ^{13}C NMR) revealed the presence of compounds **5** and **6** in a ratio of 4: 1. Selected assignments of the two compounds are as follows.

Zwitterion 5: ^1H NMR ([D_6]DMSO): δ = 3.95 (s, 3 H, CH_3-N2), 6.14 (s, 1 H, 5-H), 6.88 (m, 1 H, 4′-H), 7.30 (m, 1 H, 5′-H), 7.4−7.6 (m, 3 H, 3′′-,4′′-,5′′-H), 7.91 (dd, *J* = 8.0, 1.5 Hz, 1 H, 6′-H), 8.07 (dd, *J* = 8.0, 1.5 Hz, 1 H, 3′-H), 8.1−8.2 (m, 2 H, 2′′-,6′′-H). ^{13}C NMR ([D_6]DMSO): δ = 51.1 (CH_3-N2), 103.2 (C-5), 117.6 (C-6′), 119.4 (C-4′), 124.6 (C-2′), 127.9 (C-3′′,4′′,5′′), 128.8 (C-2′′,6′′), 130.8 (C-5′), 131.2 (C-1′′), 132.1 (C-3′), 142.8 (C-1′), 151.6 (C-3), 157.6 (C-6), 168.4 (C-4), 171.5 (COOH).

Compound 6: ^1H NMR ([D_6]DMSO): δ = 4.18 (s, 3 H, CH_3-N1), 6.48 (s, 1 H, 5-H), 7.54 (m, 1 H, 6′-H), 7.78 (m, 1 H, 5′-H), 8.08 (d, *J* = 8.0 Hz, 1 H, 3′-H). ^{13}C NMR ([D_6]DMSO): δ = 45.8 (CH_3-N1), 102.5 (C-5), 127.4 (C-2′), 133.5 (C-3′), 135.6 (C-5′), 138.3 (C-1′), 148.4 (C-3), 154.8 (C-6), 162.9 (C-4), 168.8 (COOH).

Methylation of the Mixture of 5 and 6 with Diazomethane: To a stirred solution of the crude reaction product containing **5** and **6** (1.3 g) in absolute methanol (25 mL), an ethereal solution of diazomethane (0.35 g) was added at 10 °C. Completion of the reaction was indicated by the appearance of a yellow colour due to the excess reagent. A clear solution was formed, the excess diazomethane was decomposed by adding acetic acid, the solvents were evapor-

Table 1. Crystal data and structure refinement of compounds **1**, **2**, and **3**

Compound	**1**	**2**	**3**
Empirical formula	$C_{17}H_{11}N_3O_2$	$C_{18}H_{13}N_3O_2$	$C_{18}H_{13}N_3O_2$
Molecular mass	289.29	303.31	303.31
Crystal system	monoclinic	monoclinic	monoclinic
Space group	$P2_1/n$	$P2_1/n$	$C2/c$
Unit cell dimensions			
a [Å]	7.314(1)	7.546(1)	10.705(1)
b [Å]	10.329(1)	7.529(1)	11.058(1)
c [Å]	17.984(1)	25.539(1)	23.493(1)
β [°]	91.12(1)	91.38(1)	95.64(1)
Volume [$Å^3$]	1358.4(2)	1450.5(3)	2767.5(4)
Z	4	4	8
$D_{calcd.}$ [Mg/m^3]	1.42	1.39	1.46
μ [mm^{-1}]	0.78	0.76	0.8
F(000)	600	632	1264
Crystal colour	colourless	yellow	colourless
Crystal description	prism	prism	plate
Crystal size [mm]	0.40 × 0.20 × 0.10	0.40 × 0.30 × 0.25	0.35 × 0.24 × 0.09
Absorption correction	ψ-scan	ψ-scan	ψ-scan
Max./min. transmission	0.9889/0.9112	0.9768/0.9170	1.0123/0.8213
θ range for data collection [°]	4.92 ≤ θ ≤ 75.03	3.46 ≤ θ ≤ 75.03	5.77 ≤ θ ≤ 74.96
Index ranges	$-9 \le h \le 9$	$-9 \le h \le 0$	$-13 \le h \le 13$
	$-12 \le k \le 0$	$-9 \le k \le 0$	$-13 \le k \le 13$
	$0 \le l \le 22$	$-31 \le l \le 31$	$-29 \le l \le 29$
Reflections collected	2659	2936	2752
Standard reflections	3	3	3
Decay (%)	1	4	0
Independent reflections, *R*(int)	2659, 0.0131	2936, 0.0122	2752, 0.0231
Reflections [$I > 2\sigma(I)$]	2169	2553	2286
Data/parameters	2659/200	2936/210	2752/210
Goodness-of-fit on F^2	1.11	1.1	1.06
Final *R*1, *wR*2 [$I > 2\sigma(I)$]	0.0353, 0.1028	0.0370, 0.1093	0.0412, 0.1200
*R*1, *wR*2 (all data)	0.0450, 0.1076	0.0419, 0.1126	0.0481, 0.1252
Extinction coefficient	0.0062(7)	0.0157(10)	0.00052(16)
Largest diff. peak/hole [e·$Å^{-3}$]	0.159/−0.140	0.280/−0.127	0.197/−0.204

ated, and the residue was separated by chromatography on silica eluting with chloroform.

Zwitterion 8: Yield: 500 mg (37%), m.p. 178−180 °C. ^{1}H NMR ($CDCl_3$): δ = 3.90 (s, 3 H, CH_3), 3.95 (s, 3 H, CH_3), 6.60 (s, 1 H, 5-H), 6.93 (td, 1 H, *J* = 7.0, 1.5 Hz, 4′-H), 7.39−7.42 (m, 2 H, Ph), 7.45−7.56 (m, 4 H, 5′-H and Ph), 8.00 (dd, *J* = 8.0, 1.5 Hz, 1 H, 3′-H), 8.02 (dd, *J* = 8.0, 1.5 Hz, 1 H, 6′-H). ^{13}C NMR ($CDCl_3$): δ = 50.7 ($COOCH_3$), 52.4 (CH_3-N2), 106.1 (C-5), 114.9 (C-2′), 118.6 (C-6′), 120.5 (C-4′), 129.2 (C-2′′,3′′,5′′,6′′), 130.3 (C-1′′), 130.4 (C-4′′), 131.7 (C-5′), 134.3 (C-3′), 143.6 (C-1′), 152.7 (C-1′′), 157.1 (C-6), 168.9 (C-4), 169.7 ($COOCH_3$). IR (KBr): $\tilde{\nu}$ = 3048, 1693, 1612, 1583, 1515, 1458, 1253, 1233 cm^{-1}. MS: calcd. 335.126992; found 335.126400.

Compound 9: Yield: 14 mg (11%), m.p. 135−137 °C. ^{1}H NMR ($CDCl_3$): δ = 3.55 (s, 3 H, N′-CH_3), 3.78 (s, 3 H, CH_3-N1), 3.85 (s, 3 H, $COOCH_3$), 5.80 (s, 1 H, 5-H), 6.87 (d, *J* = 10.0 Hz, 1 H, 6′-H), 7.02 (t, 1 H, 4′-H), 7.26−7.48 (m, 4 H, 5′-,3"-,4"-,5"-H), 7.60−7.68 (m, 2 H, 2"-,6"-H), 7.88 (d, *J* = 10.0 Hz, 1 H, 3′-H). ^{13}C NMR ($CDCl_3$): δ = 41.5 (CH_3-N′), 51.5 (CH_3-N1), 55.2 ($COOCH_3$), 96.1 (C-5), 121.6 (C-6′), 123.4 (C-1"), 124.3 (C-5′), 127.9 (C-3′′,5"), 128.5 (C-2′′,6"), 133.0 (C-3′), 131.2 (C-4′), 133.2 (C-2′), 138.6 (C-1′),151.0, 150.9 (C-3,6), 156.3 (C-4), 167.5 ($COOCH_3$).

X-ray Crystallographic Study: Data were collected with an Enraf−Nonius CAD4 diffractometer using Cu-K_α radiation (λ = 1.54180 Å) at room temperature (Table 1). The structures were solved by direct methods[12] and refined by anisotropic full-matrix least squares on F^2 for the non-hydrogen atoms.[13] Hydrogen atom positions were generated from assumed geometries, except for the N−H hydrogen atom in **1**, which was located in a difference map. Molecular diagrams[14] are presented in Figure 1. Crystallographic data (excluding structure factors) for the structures reported in this paper have been deposited with the Cambridge Crystallographic Data Centre as supplementary publication no. CCDC-173292 (**3**), -173293 (**2**), -173294 (**1**). Copies of the data can be obtained free of charge on application to CCDC, 12 Union Road, Cambridge CB2 1EZ, UK [Fax: (internat.) + 44-1223/336-033; E-mail: deposit@ccdc.cam.ac.uk].

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