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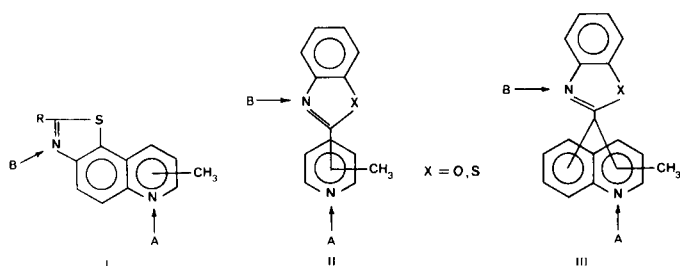
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The quaternisation of 2-(methylpyridyl or quinoly)benz-X-azoles mainly leads to the corresponding pyridinium and quinolinium salts, from which polymethine dyes are prepared. The electronic spectra and the methyl protons chemical shifts are briefly discussed.

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Heterocyclic azine and azole nuclei may be connected in many ways. We previously studied the type I fused systems (2), and recently the systems II and III (3).



The reactivity of these molecules towards quaternising agents, owing to the presence of azine (A arrows) and azole (B arrows) nitrogens, represents a typical aspect in their chemistry.

Type I bases gave salts, except in one case, at the A site and the corresponding polymethine dyes were prepared (4-7). In this paper we describe the quaternisation of II and III bases (X = O, S) and the preparation of the related styryl and unsymmetrical dyes.

The bases of types II and III show quaternisation generally at the A sites, in agreement with the basicity of isolated systems (*i.e.*, pyridines and quinolines > benzazoles). The reactions however require reaction times longer than those of the related methylpyridines and methylquinolines and the yields are generally lower. Benzoxazole derivatives (X = O) follow this rule regardless of their position in the azine rings; benzothiazole derivatives (X = S) exceed this rule only when they are linked to the α positions of the azine rings. This behaviour is reasonable on the basis of electronic and steric effects, as benzothiazole shows both greater basicity and steric hindrance than benzoxazole. It is well known from kinetic studies on quaternisation (8) that the presence of bulky alkyl groups in the α position of pyridine gives rise to a large decrease of the reaction rates, while the situation is reversed when the groups are in the γ -position.

Structures, physical constants, analysis and spectra of methiodides are listed in Table I. Compounds 16, 17, 18 are benzothiazolium salts whose formation could be ascribed to steric hindrance of the benzothiazolyl group on the azine nitrogen and to the facility of attack of the reactant to the benzothiazole nitrogen. The analogous benzoxazole compounds (3, 4, 11) are, as expected, pyridinium and quinolinium methiodides.

The assignment of the structure of the salts is made on the basis of chemical and spectroscopic evidence. When quaternisation occurs in the azine nuclei, the enhanced reactivity of the methyl groups towards aldehydes allows the formation of polymethine dyes; on the contrary, if the benzazole nucleus is quaternised, the reactivity of the methyl groups is too weak to give, under the usual conditions, a polymethine dye. In effect the dyes, reported in Table II, are obtained from pyridinium and quinolinium methiodides (1-15).

^1H nmr spectroscopy is a very useful tool to characterize the quaternary salts. The spectra of the salts (Table I) show two signals related to methyl protons. The downfield signals (in the range 4.98-5.66 τ) are assigned to $^+\text{N-CH}_3$ protons, which appear slightly deshielded with respect to the corresponding protons in methylpyridinium and methylquinolinium methiodides (5, 6, 14, 15); the upfield ones (in the range 6.76-7.25 τ excluding compounds 16, 17, 18) are assigned to C-CH_3 protons, which are also slightly more deshielded than the corresponding protons in reference compounds 5, 6, 14, 15. The $\Delta\delta$ values of the compounds 1-4 (Table I) are consistent with the values of the reference compounds 5, 6; the same behaviour

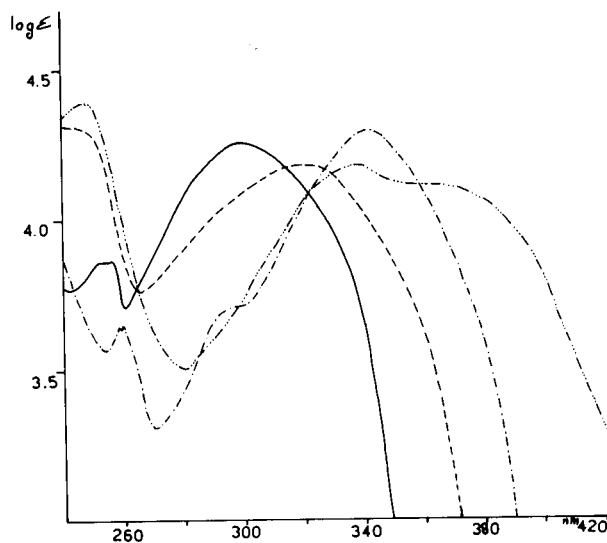
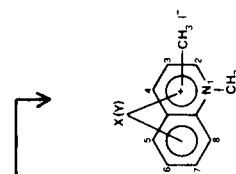


Figure 1. Electronic absorption spectra of compounds: —····— methiodide No. 2 (— free base), —····— methiodide No. 8 (— free base).

Table I
Methiodides

Compound number	Structure	M.p. °C	Empirical formula	Elemental Analyses				Electronic absorption spectra λ max, nm (log ε)	Nmr spectra τ C-CH ₃ (ppm)	Nmr spectra τ N ⁺ -CH ₃ (ppm)	Δδ (a) (Hz)		
				C%	H%	N%	Found					Calcd.	Found
1	4-X 2-CH ₃	279-280	C ₁₄ H ₁₃ IN ₂ O	47.75	47.68	3.72	3.80	7.95	8.03	336 (4.33)	7.03	5.63	22.8
2	4-Y 2-CH ₃	253-254	C ₁₄ H ₁₃ IN ₂ S	45.66	45.70	3.56	3.51	7.61	7.63	340 (4.30)	7.06	5.66	20.4
3	2-X 6-CH ₃	196-197	C ₁₄ H ₁₃ IN ₂ O	47.75	47.59	3.72	3.82	7.95	7.90	335 (4.26)	7.00	5.38	23.4
4	2-X 4-CH ₃	186-187	C ₁₄ H ₁₃ IN ₂ O	47.75	47.61	3.72	3.79	7.95	7.99	332 (4.31)	7.25	5.25	18.6
5(b)	- 2-CH ₃									265 (3.78)	7.20	5.68	17.4
6(c)	- 4-CH ₃									255 (3.81)	7.40	5.63	18.0
7	4-X 2-CH ₃	225-226	C ₁₈ H ₁₅ IN ₂ O	53.75	53.78	3.76	3.71	6.96	7.03	370 (4.29); 342 (4.29)	6.76	5.43	28.2
8	4-Y 2-CH ₃	228-230	C ₁₈ H ₁₅ IN ₂ S	51.68	51.70	3.61	3.65	6.70	6.73	360 (4.12); 336 (4.18)	6.78	5.45	27.0
9	6-X 2-CH ₃	242-243	C ₁₈ H ₁₅ IN ₂ O	53.75	53.64	3.76	3.82	6.96	6.99	363 (3.99); 347 (4.03)	6.78 (e)	5.33	27.0
10	6-Y 2-CH ₃	234-235	C ₁₈ H ₁₅ IN ₂ S	51.68	51.59	3.61	3.68	6.70	6.74	297 (4.49); 251 (4.35)	6.83 (e)	5.44	25.2
11	2-X 4-CH ₃	180-181	C ₁₈ H ₁₅ IN ₂ O	53.75	53.67	3.76	3.84	6.96	7.02	347 (4.10); 299 (4.50)	6.83	4.98	22.2
12	6-X 4-CH ₃	268-269	C ₁₈ H ₁₅ IN ₂ O	53.75	53.79	3.76	3.73	6.96	6.95	369 (4.22); 299 (3.95)	6.80	5.26	25.8
13	6-Y 4-CH ₃	255-256	C ₁₈ H ₁₅ IN ₂ S	51.68	51.75	3.61	3.55	6.70	6.67	289 (3.94); 249 (4.39)	6.80 (e)	5.26	24.0
14(d)	- 2-CH ₃									349 (4.05); 295 (4.50)	6.89	5.50	25.2
15(d)	- 4-CH ₃									242 (4.39)	6.97	5.36	21.0



Compounds 7-15

General Structure

Compounds 1-6

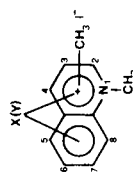
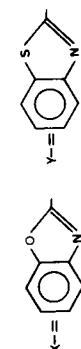


Table II

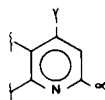
Polymethine Dyes

Compound number	Compounds 19-30		Compounds 31-46		Electronic absorption spectra λ max, nm (log ϵ)	Electronic absorption spectra λ max, nm (log ϵ)			
	Structure	M.p. °C (solvent (a))	Structure	M.p. °C (solvent (a))					
19		240-241 (b)		240-241	4-X 2-Z	589 (4.65)	4-X 2-Z	240-241	589 (4.65)
21		239-240		258-259	4-Y 2-Z	585 (4.71)	4-Y 2-Z	258-259	585 (4.71)
23		220-222 (b)		217-219 (c)	2-X 6-Z	568 (4.23)	2-X 6-Z	217-219 (c)	568 (4.23)
25		200-201		211-212	2-X 4-Z	601 (4.92)	2-X 4-Z	211-212	601 (4.92)
27 (d)					- 2-Z	536 (4.93)	- 2-Z		536 (4.93)
29 (d)					- 4-Z	557 (4.98)	- 4-Z		557 (4.98)
31		245-246		245-246	4-X 2-Z	613 (4.78)	4-X 2-Z	245-246	613 (4.78)
33		219-220		266-267	4-Y 2-Z	609 (4.86)	4-Y 2-Z	266-267	609 (4.86)
35		279-280		283-284	6-X 2-Z	600 (5.16)	6-X 2-Z	283-284	600 (5.16)
37		272-273		280-281	6-Y 2-Z	601 (5.17)	6-Y 2-Z	280-281	601 (5.17)
39		260-261		283-284	6-X 4-Z	657 (5.14)	6-X 4-Z	283-284	657 (5.14)
41		250-251		264-265	6-Y 4-Z	658 (5.15)	6-Y 4-Z	264-265	658 (5.15)
43 (f)					- 2-Z	582 (5.12)	- 2-Z		582 (5.12)
45 (f)					- 4-Z	630 (5.14)	- 4-Z		630 (5.14)

(a) Crystallized from ethanol. (b) Crystallized from water and successively from methanol. (c) Crystallized from methanol. (d) Reference 16. (e) Reference 17. (f) Reference 18. (g) Reference 19.

significant patterns, pairing any methiodide to the corresponding base (3). Figure 1 shows the spectra of the compounds **2** and **8** in which a 2-benzothiazolyl group is linked to the γ -position of the azine ring; the spectral pattern of the bases is essentially retained in pyridinium methiodides, while the main absorption of quinolinium methiodides is split into two maxima. Quaternisation results in a marked bathochromic shift with a weak hyperchromic effect. The spectra of compounds **10** and **13** in which a 2-benzothiazolyl is linked to the 6 position of quinoline (Figure 2) are characterised by three main bands (the central one is more intense) with a typical pattern with respect to the corresponding bases. In the spectra of benzothiazolium type salts (Figure 3; compounds **16** and **18**) the pattern of the bases is remarkably retained with a strong hypochromic effect accompanied by a shift of the absorption to shorter wavelengths.

As reported above, the pyridinium and quinolinium quaternary salts were condensed with *p*-dimethylaminobenzaldehyde and with (3-methyl-2-benzothiazolynilydene)ethanal to give *p*-dimethylaminostyryl dyes and unsymmetrical thiacyanines, respectively. In Table II, structure, melting points, spectra and sensitometric data of dyes are reported. According to the longer chromophoric chain and to the possibility of a more extended conjugation, dyes with the γ -linked polymethine portion absorb, as expected, at longer wavelengths than α isomers.



The same effect is revealed by a comparison between the quinoline dyes and the corresponding pyridine ones. The presence of a benz-X-azolyl in pyridine and quinoline nuclei is accompanied by a bathochromic effect (18-66 nm), being styryl dyes more affected than unsymmetrical dyes.

The styryl dyes were tested as sensitizers for photographic emulsions. From data in Table II a loss of the sensitizing properties of dyes is observed when a benz-X-azolyl is present. This could be due to a combined effect of the electron withdrawing properties of the benz-X-azolyl (9,10) and of its hindrance to the package of the molecules on silver halide grains.

EXPERIMENTAL

Nmr spectra were obtained with a Jeol C-60 HL spectrometer, in DMSO- d_6 solution (6%) using TMS as internal standard. Electronic spectra were recorded, in ethanol, on a Unicam SP 1700 spectrophotometer.

Methiodides.

Compounds **1-15** and **17** were prepared refluxing the corresponding free bases (3) with a strong excess of methyl iodide over a period of 3-4 hours. For quinoline derivatives (**7-13**), it is

preferable to carry the reaction in presence of acetone. The crude products were collected, washed with ethyl ether, and crystallized from ethanol. The quaternisation to compounds **16** and **18** was performed with an excess of methyl iodide in a sealed tube (105°, 12 hours), ethyl ether was added and the recovered methiodide was crystallized from ethanol.

The yields were in the range 60-70% for methiodides **1-15** and in the range 15-20% for methiodides **16-18**.

Dyes.

The dyes were prepared by refluxing a suitable methiodide (3×10^{-3} mole) for 45 minutes in acetic anhydride (20 ml. for pyridinium salts and 40 ml. for quinolinium salts) with *p*-dimethylaminobenzaldehyde (3.5×10^{-3} mole) (styryl dyes) or (3-methyl-2-benzothiazolynilydene)ethanal (**11**) (3.5×10^{-3} mole) (unsymmetrical dyes). Cyanines from methiodide **3** were obtained by reaction in absolute ethanol (piperidine as catalyst) under milder conditions (45°, 30 minutes). Dyes from methiodide **11** were not recovered owing to decomposition during the reaction. The crude products were collected, washed with ethyl ether, and crystallized as indicated in Table II.

Sensitometric Tests.

The dyes were tested as sensitizers for bromo-chloride type photographic emulsions following standard procedures. The results of the relative sensitivity data are expressed as log E (E = exposure) (sign minus means lower sensitivity and sign plus means higher sensitivity in comparison with the test emulsion not containing the dye).

REFERENCES AND NOTES

- (1) This work was supported by the National Research Council (CNR).
- (2) G. Di Modica, E. Barni, F. Delle Monache, *J. Heterocyclic Chem.*, **2**, 242 (1965).
- (3) E. Barni and P. Savarino, *ibid.*, **14**, 937 (1977).
- (4) E. Barni, G. Di Modica, A. Gasco, F. Delle Monache, *Tetrahedron Letters*, 3867 (1966).
- (5) G. Di Modica, E. Barni, A. Gasco, *Atti Accad. Sci. Torino*, **101**, 139 (1967).
- (6) E. Barni, A. Gasco, G. Di Modica, F. Delle Monache, *Boll. Sci. Fac. Chim. Ind. Bologna*, **25**, 107 (1967).
- (7) E. Barni, G. Di Modica, A. Gasco, *ibid.*, **25**, 87 (1967).
- (8) H. C. Brown, A. Cahn, *J. Am. Chem. Soc.*, **77**, 1715 (1955).
- (9) V. F. Bystrov, Zh. N. Belaya, B. E. Gruz, G. P. Syrova, A. J. Tolmachev, L. M. Shulezhko, L. M. Yagupol'skii, *Zhur. Obshch. Khim.*, **38**, 1001 (1968); *Chem. Abstr.*, **69**, 96568q (1968).
- (10) E. Barni, P. Savarino, G. Di Modica, *Atti Accad. Sci. Torino*, **107**, 63 (1973).
- (11) I. G. Farbenind A. G., British Patent 486,780 (1936).
- (12) E. M. Kosower, J. A. Skorcz, *J. Am. Chem. Soc.*, **82**, 2195 (1960).
- (13) L. W. Deady, G. D. Willett, *Org. Magn. Reson.*, **6**, 53 (1974).
- (14) E. D. Bergmann, F. E. Crane, Jr., R. M. Fuoss, *J. Am. Chem. Soc.*, **74**, 5979 (1952).
- (15) D. Sutherland, C. Compton, *J. Org. Chem.*, **17**, 1257 (1952).
- (16) G. R. Clemo, G. A. Swan, *J. Chem. Soc.*, 1454 (1938).
- (17) A. I. Kiprianov, G. G. Dyadyusha, *Zhur. Obshch. Khim.*, **30**, 3647 (1960); *Chem. Abstr.*, **55**, 22833g (1961).
- (18) J. Metzger, H. Larivè, R. Dennilauler, R. Baralle, C. Gaurat, *Bull. Soc. Chim. France*, 1284 (1969).