4-CYANOPYRIDOBENZAZOLIUM AND 1-CYANOQUINOLIZINIUM SALTS FROM PROTONATED 2-CYANOMETHYLAZAHETEROCYCLES AND β-DIKETONES

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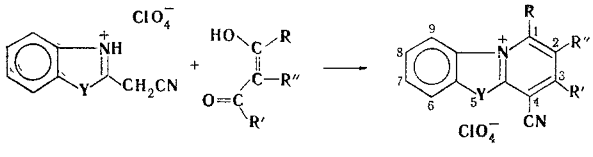
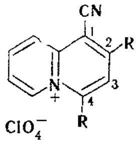
2-Cyanomethyl-1-methylbenzimidazolium, 2-cyanomethylbenzothiazolium, 2-cyanomethylbenzoxazolium, and 2-cyanomethylpyridinium perchlorates react with β-diketones to give the corresponding 4-cyanopyridobenzazolium and 1-cyanoquinolizinium salts, which give polymethine dyes through the methyl groups in the α and γ positions of the pyridine ring.

2-Cyanomethylbenzimidazole reacts with β-diketones to give 4-cyanopyrido[1,2-a]benzimidazoles [1]. We have found that the reaction also proceeds similarly for 1-methyl-2-cyanomethylbenzimidazolium salts, and pyrido[1,2-a]benzimidazolium derivatives II (Y = N—CH_3) are formed. In addition, it was found that this reaction can be extended to other benzazoles, pyridine, and, in general, apparently to practically all 2-cyanomethylazaheterocycles. In the present study we obtained 4-cyano-substituted pyrido[1,2-a]benzimidazolium, oxazolo- and thiazolo[3,2-a]pyridinium (II), and 1-cyanoquinolizinium salts (III).



I a-c II a-j



III a-c

a Y=N—CH_3; b Y=S; c Y=O

2-Cyanomethylheterocycle perchlorates undergo cyclization with β-diketones when the components are heated; the reaction products, which have methyl groups in the α and (or) γ positions of the pyridine ring, give polymethine dyes, and this may serve as a qualitative test for the occurrence of a reaction to give a pyridinium salt.

The assignment of the signals of the methyl groups in the PMR spectra of salts II and III (see Table 1) is confirmed by the spectrum (see Fig. 1) of the product (IId) of condensation of Ia with benzoylacetone, which is a mixture of isomers in a ratio of 1:2.5 in the crude product and 1:2 in the analytically pure product; this was determined by integration of the signals of the methyl groups at 2.99 and 2.52 ppm. Two doublets at 8.11 and 6.29 ppm with J = 8.5 Hz and an intensity ratio of ∿ 1:2 are observed in this spectrum. The proton in the 9 position gives both of these doublets, and a signal at weak field is observed for all salts II, whereas a signal at strong field appears only for IId. The strong diamagnetic shift of 9-H in one of the isomers of IId is explained by the fact that the phenyl group in this isomer is in the 1 position and shields 9-H; this was also previously observed in similar molecular fragments [2].

Benzoylacetone reacts with Ib to give one isomer — IIg (δ 3-CH_3 at 2.63 ppm). Methyl acetylpyruvate reacts with Ia and Ib and 2-cyanomethylpyridinium perchlorate to give one

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TABLE 1. Pyridinium Salts II-V

Compound	R	R′	R″	mp, °C	Empirical formula	Found, %		Calc., %		δ_{CH_3}, ppm		Yield, %
						Cl	N	Cl	N	1-	3-	
IIa	CH₃	CH₃	H	249—250	$C_{15}H_{14}ClN_3O_4$	10,8	12,5	10,6	12,5	2,88	2,46	88
Y=N—CH₃												
IIb	CH₃	CH₃	CH₃	246	$C_{16}H_{16}ClN_3O_4$	10,2	12,1	10,2	12,0	2,98	2,57	91
IIc	CH₃	CO₂CH₃	H	265—267	$C_{16}H_{14}ClN_3O_6$	9,6	10,8	9,3	11,1	3,00	—	86
IId	CH₃ (C₆H₅)	C₆H₅ (CH₃)	H	232—238	$C_{20}H_{16}ClN_3O_4$	8,8	10,7	8,9	10,6	2,99	2,52	85
IIe	CH₃	CH₃	H	265	$C_{14}H_{11}ClN_2O_4S$	10,5	8,4	10,5	8,3	3,15	2,57	80
Y=S												
IIf	CH₃	CH₃	CH₃	265—266	$C_{15}H_{13}ClN_2O_4S$	10,3	8,9*	10,0	9,1	—	—	77
IIg	C₆H₅	CH₃	H	225—228	$C_{19}H_{13}ClN_2O_4S$	8,9	7,9*	8,8	8,0	—	2,63	100
IIh	C₆H₅	C₆H₅	H	215	$C_{24}H_{15}ClN_2O_4S$	7,8	7,0*	8,0	7,1	—	—	50
IIi	CH₃	CO₂CH₃	H	260	$C_{15}H_{11}ClN_2O_6S$	9,3	8,4*	9,3	8,4	3,23	—	100
IIj	CH₃	CH₃	H	261	$C_{14}H_{11}ClN_2O_5$	11,1	8,7	11,0	8,7	3,02	2,63	74
Y=O										2—	4—	
IIIa	H	H	H	193—194	$C_{10}H_7ClN_2O_4$	13,8	—	13,9	—	—	—	8
IIIb	CH₃	CH₃	—	219—220	$C_{12}H_{11}ClN_2O_4$	12,4	9,8	12,5	9,9	2,58	2,78	46
IIIc	CH₃	CO₂CH₃	—	203	$C_{13}H_{11}ClN_2O_6$	11,2	8,3	10,8	8,6	—	2,88	77
IV	—	—	—	>360	$C_{15}H_{12}N_2O_4$	—	10,2	—	9,9	—	—	68
V	—	—	—	248	$C_{16}H_{18}ClN_3O_5$	—	11,7	—	11,4	—	—	82

*S, %.

†A mixture of isomers

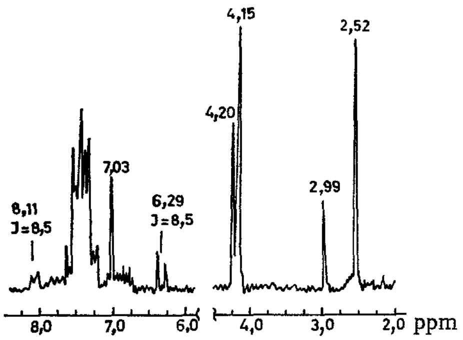


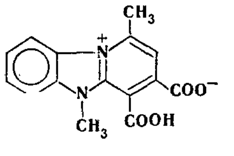
Fig. 1. PMR spectrum of IIa

isomer with a methyl group in the α position; this was determined from the magnitude of the chemical shift of this group.

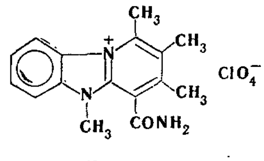
A quaternary salt, which was converted to a perchlorate that proved to be identical to salt IIa, was obtained from the reaction of dimethyl sulfate with 4-cyano-1,3-dimethylpyrido[1,2-a]benzimidazole [1].

2-Cyanomethylpyridinium perchlorate reacts with 1,1,3,3-tetraethoxypropane on heating in alcohol to give 1-cyanoquinolizinium perchlorate (IIIa) in addition to a red dye in low yield.

Salts IIb and IIc were subjected to acid hydrolysis. The nitrile group vanishes (according to the IR spectra) in both cases. Salt IIc is converted to betaine IV, i.e., both the nitrile and the ester group are hydrolyzed; amide V was obtained from IIb.



IV



V

EXPERIMENTAL METHOD

The PMR spectra of trifluoroacetic acid solutions of the compounds were recorded with a ZKR-60 spectrometer with hexamethyldisiloxane as the internal standard.

Condensation of 2-Cyanomethylheterocycle Perchlorates with β-Diketones. A mixture of components with a 15-20% excess of the β-diketone was heated for 15-20 min (IIc,e,f,g,i and IIIc), 30 min (IIa,d,j), 1h (IIn and IIIb), or 1.5 h (IIb) at a bath temperature of 120° (IIi, j), 170-180° (IIIb, c), or 140-150° (for all of the remaining products). As a rule, crystals of the reaction product were isolated from the hot solution. The solutions were cooled, and the precipitates were washed repeatedly with ether and recrystallized from alcohol–nitromethane (2:1) (IIa-j) or from methanol (IIIa-c).

1,3,5-Trimethyl-4-cyanopyrido[1,2-a]benzimidazolium Methosulfate. A 0.74-g (3.3 mmole) sample of 4-cyano-1,3-dimethyl[1,2-a]benzimidazole and 0.45 ml (3.6 mmole) of dimethyl sulfate were dissolved by heating in a mixture of 5 ml of trichloroethylene and 7 ml of nitromethane, and the solution was refluxed for 3.5 h. It was then cooled, 10 ml of ether was added, and the resulting precipitate was removed by filtration to give 0.81 g (70%) of a product with mp 207° (from alcohol). Found%: S 9.2. $C_{16}H_{17}N_3O_4S$. Calculated %: S 9.2. The perchlorate of this product was identical to IIa.

1-Cyanoquinolizinium Perchlorate. A 2.3-mmole sample of 2-cyanomethylpyridinium perchlorate was dissolved in 0.5 ml of methanol, 2.5 mmole of tetraethoxypropane was added, and the mixture was refluxed for 1 h. It was then cooled, and 10 ml of methanol was added to the red solution. The resulting precipitate was removed by filtration and washed with alcohol and ether.

Hydrolysis of IIb,c. A 1.3-mmole sample of IIb (for 28 h) or IIc (for 17h) was refluxed in 2 ml of sulfuric acid–acetic acid–water (3:4:3). The mixture was then cooled, 2 ml of water was added, and the precipitate was removed by filtration. Compound V was recrystallized from nitromethane–ethanol (1:2), whereas IV was recrystallized from nitromethane.

LITERATURE CITED

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2. D. W. Dunwell and D. Evans, J. Chem. Soc., C, 2094 (1971).