VINAMIDIUM SALTS HAVING A FURAN RING AND THEIR SUBSTITUTION ELECTROPHILIC REACTIONS

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5-(N,N-Dialkylamino)-2-furfurylidene-N,N-dialkylimmonium salts *I* (the so called vinamidinium salts) are characteristic of their reactivity towards electrophilic reagents. A series of new furan derivatives with substituents in β-position of the furan ring were prepared *via* this reagent. The presented reactions involve halogenation, nitration, formylation and acylation with the Vilsmeier-type reagents.

This paper concerns some electrophilic displacement reactions with 5-(N,N-dialkylamino)-2-furfurylidene-N,N-dialkylimmonium salts *I* (ref.[1]). Compounds of this type can be classified as the so called vinamidinium salts[2] having a furan ring. In favour of this fact are the high wavelength values λ_{max} 395–418 nm comparable with those of heptamethinium salts (λ_{max} 416, ref.[3]). Vinamidinium salts are characteristic of a considerable delocalization of electrons and consequently, of a high stability on one hand, and a noticeable reactivity towards electrophilic reagents on the other[4,5].

The furan ring, embodied in these salts into the polymethinium system, undergoes a series of electrophilic substitution reactions in β-position under experimental condition unfavourable, in general, for furan derivatives. Thus *e.g.* the direct formylation of β-position of the furan ring was reported successful in low yield only (up to 40%) with 2,5-diphenylfuran[6], 5-alkyl-2-(alkylthio)-furan[7,8], and 2,5-bis(alkylthio)furan[8]. Salts *I* are easily available and are, therefore, valuable synthons for preparation of some new types of furan derivatives with functional groups located in β-position. Compound *I* reacted with the Vilsmeier-type of formylation reagent under conditions of a mild formylation (60–70°C) to afford the corresponding derivative, which can be isolated as a bisperchlorate *II*; the latter gave, when hydrolyzed, 5-(N,N-dialkylamino)-2,4-furandicarbaldehydes *III* in high yields (Table I).

Acylation of *Ia* was under these conditions successful with acid amides having substituents at C_α thus enhancing the electrophility of the Vilsmeier-type reagent and gave *IV*; the lowering electrophility of the reagent (CF_3, $CHCl_2$, CH_2Cl) re-

sulted in lowering the yields. Reactivity of salts *I* towards electrophilic reagents was confirmed also by halogenation under formation of 4-bromo or 4-iodo-5-(N,N-dimethylamino)-2-furancarbaldehyde *V*, and by nitration affording 4-nitro-5-(N,N-dimethylamino)-2-furancarbaldehyde (*VI*).

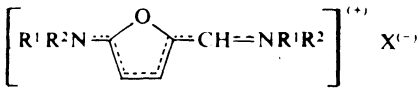
The compounds prepared were identified by elemental analysis, ^{1}H NMR, IR, and UV spectra. The resonance signals of aldehyde group protons at $C_{(2)}$ (δ 9·22, s) and $C_{(4)}$ (δ 9·67, s) of the furan ring of compound *IIIa* were attributed by comparing the ^{1}H NMR spectrum with that of the deuterated *IIIa* obtained from perdeuterated N,N-dimethylformamide and deuteriowater.

EXPERIMENTAL

Melting points were measured on a micro-hot-stage, the IR and UV spectra were recorded with a UR-20 (Zeiss, Jena) spectrophotometer in 0·26 mm-cells in chloroform at a 10^{-2} mol l^{-1} concentration, and with a UV-VIS (Zeiss, Jena) apparatus in 10 mm-cells in methanol at a 5 . 10^{-5} mol l^{-1} concentration, respectively. The ^{1}H NMR spectra of deuteriochloroform solutions taken with a BS 487 C (Tesla) instrument operating at 80 MHz are relative to tetramethylsilane.

TABLE I
5-(N,N-dialkylamino)-2,4-furandicarbaldehydes (*III*)

Compound	Formula (M_r)	M.p., °C (yield, %)	Calculated/Found			ν(C=O) cm^{-1}	λ_{max}, nm (log ε)	
			% C	% H	% N			
IIIa	$C_8H_9NO_3$	135—136	57·51	5·43	8·38	1 670	302	351
	(167·0)	(85)	57·50	5·61	8·37	1 646	(3·22)	(3·46)
IIIb	$C_{10}H_{13}NO_3$	74—75	61·56	6·66	7·17	1 682	309	351
	(195·0)	(81)	61·68	6·70	7·04	1 650	(3·21)	(3·46)
IIIc	$C_{10}H_{11}NO_3$	169—171	59·08	5·40	11·81	1 693	301	358
	(203·1)	(86)	60·12	5·43	10·95	1 650	(3·30)	(3·48)
IIId	$C_{10}H_{11}NO_4$	128—130	57·41	5·21	6·69	1 700	—	348
	(209·0)	(88)	56·89	5·32	6·68	1 658	—	(3·35)
IIIe	$C_{11}H_{14}NO_3$	67—68	64·49	6·72	6·72	1 702	—	350
	(208·1)	(82)	65·03	6·53	6·75	1 653	—	(3·42)
IIIf	$C_{10}H_{12}N_2O_3$	130—133	57·67	5·80	13·45	1 672	—	343
	(208·2)	(64)	57·22	5·79	13·89	1 656	—	(3·46)



Ia, $R^1R^2N = (CH_3)_2N$, X = Br

Ia', $R^1R^2N = (CH_3)_2N$, X = I

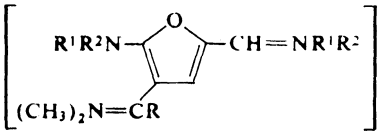
Ib, $R^1R^2N = (C_2H_5)_2N$, X = ClO_4

Ic, R^1R^2N =  , X = Br

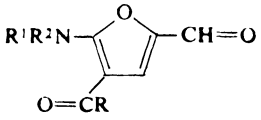
Id, R^1R^2N =  , X = Br

Ie, R^1R^2N =  , X = ClO_4

If, R^1R^2N =  , X = Br



II



III, R = H

IVa, R = CF_3

IVb, R = $CHCl_2$

IVc, R = CH_2Cl

5-(N,N-Dialkylamino)-2,4-furandicarbaldehydes *IIIa*—*IIIf*

Phosphorus oxydochloride (20 mmol) was added to a stirred and cooled N,N-dimethylformamide (20 mmol). The mixture was left to stand at room temperature for 20 min, then polymethinium salt *I* (10 mmol) was added and the content of the flask was heated to 60—70°C for 2 h and worked up by two ways:

A) The product was dissolved in ethanol (10 ml) and precipitated with perchloric acid as a bisperchlorate *II*; the precipitate was filtered off, washed with ethanol and hydrolyzed with solid potassium carbonate in water at pH 7·5 (*IIIa,b,e*).

B) The product dissolved in water (10 ml) was hydrolyzed with potassium carbonate as described under *A*) (*IIIc,d,f*), extracted with chloroform, washed with water and dried. The solvent was removed under reduced pressure and product *III* was crystallized from ethanol. Characteristic data of compounds *IIIa*—*IIIf* are listed in Tables I and II.

4-Acyl-5-(N,N-dimethylamino)-2-furancarbaldehydes *IVa*—*IVc*

Phosphorus oxydochloride (15 mmol) was added to a mixture of *Ia* (10 mmol) and the respective acid-N,N-dimethylamide (15 mmol) at 60—70°C. The mixture was stirred at this temperature for 3 h and hydrolyzed with solid potassium carbonate in water (20 ml) at pH 7·5. The product was extracted with dichloromethane, washed with water, dried and the solvent was evaporated *in vacuo*.

4-*Trifluoroacetyl*-5-(N,N-*dimethylamino*)-2-*furancarbaldehyde* (IVa): For $C_9H_8F_3NO_3$ (235·1) calculated: 45·97% C, 3·42% H, 5·95% N; found: 45·04% C, 3·40% H, 6·47% N, m.p. 91—92°C, yield 73%. ^{1}H NMR spectrum: 9·27 (s, 1 H, CHO), 7·48 (s, 1 H, H_{fur}); 3·13 (s, 6 H, CH_3). IR spectrum, cm^{-1}: ν(C=O) 1 681, 1 648.

4-*Dichloroacetyl*-5-(N,N-*dimethylamino*)-2-*furancarbaldehyde* (IVb): For $C_9H_9Cl_2NO_3$ (249·9) calculated: 43·25% C, 3·63% H, 5·60% N, 28·37% Cl; found: 43·64% C, 3·72% H, 5·91% N, 28·02% Cl. Yield 68%, oil. ^{1}H NMR spectrum: 9·03 (s, 1 H, CHO). 7·10 (s, 1 H, H_{fur}), 3·21 (s, 6 H, CH_3), 3·02 (s, 1 H, CH). IR spectrum, cm^{-1}: ν(C=O) 1 718, 1 678.

4-*Chloroacetyl*-5-(N,N-*dimethylamino*)-2-*furancarbaldehyde* (IVc): For $C_9H_{10}ClNO_3$ (215·6) calculated: 50·13% C, 4·67% H, 6·49% N, 16·44% Cl; found: 50·68% C, 4·92% H, 6·81% N, 16·32% Cl. Yield 29%, oil. ^{1}H NMR spectrum: 9·02 (s, 1 H, CHO), 7·10 (s, 1 H, H_{fur}), 3·30 (s, 6 H, CH_3), 3·20 (s, 2 H, CH_2). IR spectrum, cm^{-1}: ν(C=O) 1 705, 1 651.

4-Halo-5-(N,N-dimethylamino)-2-furancarbaldehydes *Va,b*

A mixture of *Ia*, or *Ia'* (3 mmol) and N-bromo, or N-iodosuccinimide (5 mmol) in chloroform (10 ml) was heated at reflux temperature for 10 h, concentrated under diminished pressure and hydrolyzed with aqueous sodium hydroxide (10%, 20 ml). The product was extracted with chloroform and purified by chromatography on a silica gel column, chloroform–acetone 7 : 3 being the eluent.

4-*Bromo*-5-(N,N-*dimethylamino*)-2-*furancarbaldehyde* (Va): For $C_7H_8BrNO_2$ (218·1) calculated: 38·54% C, 6·42% N, 36·66% Br; found: 38·79% C, 6·62% N, 36·81% Br, m.p. 57—58°C, yield 31%. ^{1}H NMR spectrum: 9·03 (s, 1 H, CHO), 7·15 (s, 1 H, H_{fur}), 3·20 (s, 6 H, CH_3), IR spectrum, cm^{-1}: ν(C=O) 1 650.

4-*Iodo*-5-(N,N-*dimethylamino*)-2-*furancarbaldehyde* (*Vb*): For $C_7H_8INO_2$ (265·0) calculated: 31·72% C, 5·20% N, 47·80% I; found: 32·08% C, 5·40% N, 47·65% I, m.p. 98—100°C, yield 40%. ^{1}H NMR spectrum: 9·05 (s, 1 H, CHO), 7·21 (s, 1 H, H_{fur}), 3·22 (s, 6 H, CH_3). IR spectrum, cm^{-1}: ν(C—O) 1 646.

TABLE II

^{1}H NMR Spectra of 5-(N,N-dialkylamino)-2,4-furandicarbaldehydes (*III*)

Compound	C_2HO	C_4HO	H_{fur}	Group	Others
IIIa	9·22 s	9·67 s	7·56 s	$(CH_3)_2$	3·40 s
IIIb	9·22 s	9·60 s	7·55 s	$(CH_2)_2$	3·76 q, $(CH_3)_2$ 1·32 t
IIIc	9·22 s	9·71 s	7·56 s	$N(CH_2)_2$	3·8 t, $(CH_2)_2$ 2·12 t
IIId	9·25 s	9·53 s	7·56 s	$(CH_2)_4$	3·88 m
IIIe	9·21 s	9·56 s	7·52 s	$N(CH_2)_2$	3·9 t, $(CH_2)_3$ 1·75 t
IIIf	9·30 s	9·55 s	7·52 s	$(CH_2)_4$	3·81 m, NH 8·15 s

4-Nitro-5-(N,N-dimethylamino)-2-furancarbaldehyde (*VI*)

Nitric acid (98%, 1·5 ml) was added to acetic anhydride with stirring at −20°C, then compound *Ia* (3 mmol) was added and the mixture was stirred at this temperature for 1 h. The content of the flask was hydrolyzed with aqueous sodium hydroxide (10%, 30 ml), the product was extracted with benzene and the solent was distilled off under reduced pressure. For $C_7H_8N_2O_4$ (184·1) calculated: 45·65% C, 4·37% H, 15·21% N; found: 45·71% C, 4·20% H, 15·45% N, m.p. 105 to 110°C, yield 38%. ^{1}H NMR spectrum: 9·21 (s, 1 H, CHO), 7·62 (s, 1 H, H_{fur}), 3·32 (s, 6 H, CH_3). IR spectrum, cm^{-1}: ν(C=O) 1 664 cm^{-1}, ν(NOα), 1 578, 1 355 cm^{-1}.

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