3-(5-X-2-FURYL)-2-CYANOACRYLONITRILES ON REACTION WITH 2-CYANOMETHYLBENZOTHIAZOLE

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2-Cyanomethylbenzothiazole reacts with 3-(5-X-2-furyl)-, 3-(2-thienyl)- or 3-(2-pyrrolyl)-2-cyanoacrylonitrile in tetrahydrofuran under catalysis of triethylamine to give 1-(2-benzothiazolyl)-1-cyano-2-heteroarylethylenes as a result of replacement of malonodinitrile by 2-cyanomethylbenzothiazole.

In our previous papers[1-5] dealing with furan derivatives on reaction with nucleophiles we ascertained that 5-X-2-furylethylene derivatives undergo either a nucleophilic replacement of X or an addition of the nucleophile to the C=C double bond depending on the character of the electron-accepting group at C-2 of the furan ring.

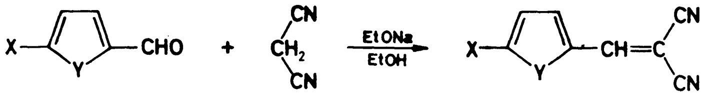
This paper describes the reaction of 3-(5-X-2-furyl)-, 3-(2-thienyl)- or 3-(2-pyrrolyl)-2-cyanoacrylonitrile with 2-cyanomethylbenzothiazole in tetrahydrofuran under catalysis of triethylamine. As found, this reaction did not afford the corresponding cyclization products – derivatives of pyrido-[2,1-*b*]benzothiazole, but 1-(2-benzothiazolyl)-1-cyano-2-heteroarylethylenes, in other words, a displacement of malonodinitrile by 2-cyanomethylbenzothiazole took place (Scheme 1).

Analogous reactions involving displacement of anions in C—H acids were described by Van Dyke and coworkers[6] and other authors[7-10]. From findings describing the course of those reactions one can conclude that a weaker C—H acid or its anion are the leaving groups. The same circumstance causing the acidity increase of C—H acids also rises the resonance stability of the alkene what might be the actual driving force replacing the groups in question.

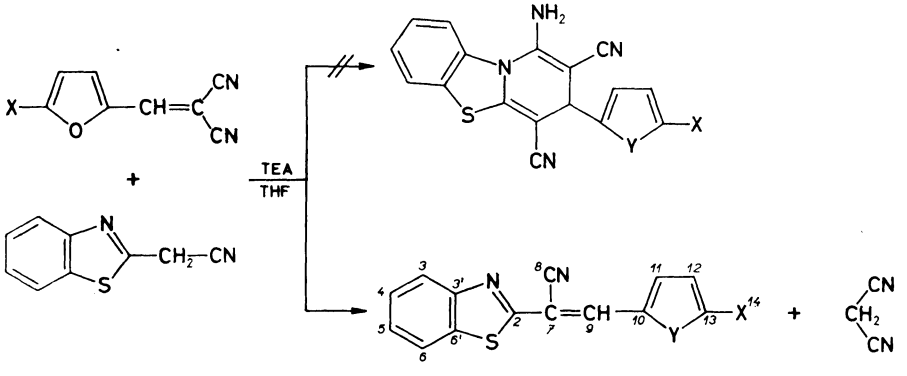
It is obvious that in this reaction precipitation of the product from solution shifts the equilibrium towards the right side (Scheme 2).

The structure of compounds *I*–*X* was corroborated through their synthesis from the corresponding heterocyclic aldehydes and 2-cyanomethylbenzothiazole in ethanol under conditions of Knoevenagel reaction in yields better than 85%.

The UV spectra of 1-(2-benzothiazolyl)-1-cyano-2-(5-X-2-heteroaryl)ethylenes (compounds *I*–*X*, Table I) reveal three absorption bands at 213–227, 256–312,



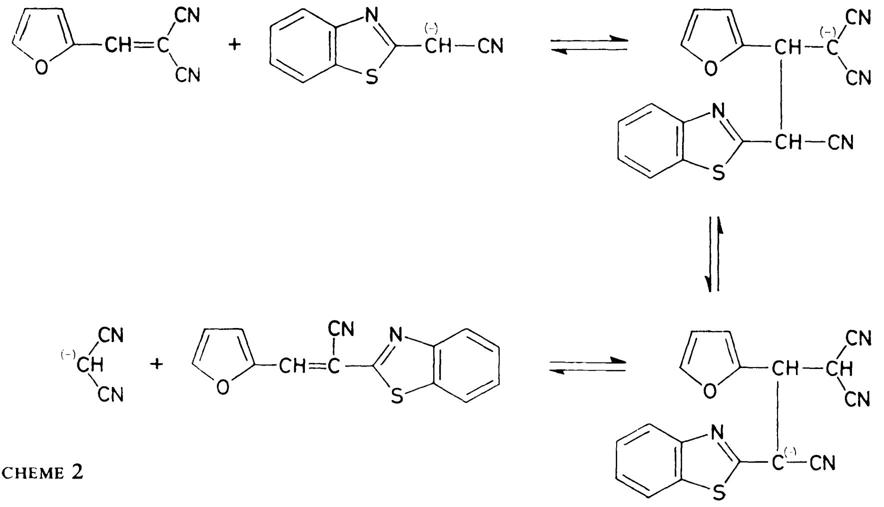
Y = O ; X = H, CH_3, $COOCH_3$, NO_2, I, Br, $N(CH_3)_2$, $SO_2C_6H_5$
Y = S ; X = H
Y = NH ; X = H



I-X

	I	II	III	IV	V	VI	VII	VIII	IX	X
X	H	Br	I	Me	NO_2	NMe_2	SO_2Ph	CO_2Me	H	H
Y	O	O	O	O	O	O	O	O	S	NH

SCHEME 1



SCHEME 2

TABLE I

Characteristic data of compounds *I*–*X*

Compound	Formula (M.w.)	M.p., °C Yield, %	Calculated/Found			λ_{max}, nm log ε		
			% C	% H	% N			
I	$C_{14}H_8N_2CS$	137–138[a]	66·64	3·20	11·10	223	256	378
	(252·3)	85	66·59	3·31	11·30	3·43	3·00	3·48
II	$C_{14}H_7BrN_2OS$	211–212[a]	50·77	2·13	8·46	220	259	385
	(331·2)	72	50·78	2·34	8·75	3·33	2·94	3·55
III	$C_{14}H_7IN_2OS$	225–227[a]	44·46	1·87	7·41	220	260	392
	(378·2)	8	44·95	2·05	7·70	3·31	2·94	3·52
IV	$C_{15}H_{10}N_2OS$	149–151[a]	67·64	3·79	10·52	223	260	389
	(266·3)	78	67·32	3·85	10·58	4·01	3·60	4·16
V	$C_{14}H_7N_3O_3S$	245–246[b]	56·66	2·38	14·14	217	312	393
	(297·3)	90	56·40	2·27	14·07	3·64	2·98	3·34
VI	$C_{16}H_{13}N_3OS$	216–218[b]	65·05	4·44	14·23	213	294	514
	(295·3)	85	64·92	4·37	14·05	3·51	2·94	4·28
VII	$C_{20}H_{12}N_2O_3S_2$	221–223[b]	61·20	3·09	7·14	218	258	370
	(392·4)	82	61·03	3·22	7·35	3·68	2·94	3·58
VIII	$C_{16}H_{10}N_2O_3S$	178–179[c]	61·92	3·25	9·03	219	258	374
	(310·3)	92	62·01	3·25	9·17	3·53	3·08	3·42
IX	$C_{14}H_8N_2S_2$	157–159[a]	62·65	3·01	10·44	221	260	374
	(268·3)	87	62·5	3·15	10·67	3·31	3·03	3·36
X	$C_{14}H_9N_3S$	176–178[a]	66·90	3·62	16·72	227	260	410
	(251·3)	78	66·95	3·71	16·75	3·43	3·21	3·64

[a] Ethanol–tetrahydrofuran; [b] dioxane; [c] ethanol–dioxane

and 370−514 nm; the first two could be ascribed to $\pi \rightarrow \pi^*$ and $n \rightarrow \pi^*$ electronic transitions localized in the furan and benzothiazole moieties of the molecule. The last absorption maximum reflects the oscillation of π-electrons throughout the whole conjugated system. The ^{1}H NMR spectra of compounds *I*−*X* (Table II) showed the signal of an olefinic proton at δ 7·62−8·65; as seen, the substituent at C-5 of the furan ring influenced its position. In agreement with the expectation, the electron-donating substituents shifted this signal towards the higher field and vice versa, this being most pronounced with $(CH_3)_2N$ (δ 7·62) and NO_2 (δ 8·55) groups, respectively.

The structure of compounds under study was also proved by the ^{13}C NMR spectra. The chemical shift values of compounds *I*−*X* are listed in Table III. For signal assignments of the unsubstituted derivatives *I*, *IX* and *X* HETCOR and INEPT

TABLE II
^{1}H NMR chemical shift data (δ, ppm)

Compound	H-12	H-11	H-9	H-arom	$J(11,12)$, Hz	Others
I	6·81 m	[a]	8·12 s	7·31−7·62 m (3 H) 7·90−8·12 m (3 H)	4	
II	6·94 d	[a]	8·06 s	7·31−7·68 m (3 H) 7·87−8·25 m (2 H)	4	
III	7·01 d	7·62 d	8·03 s	7·37−7·65 m 7·87−8·03 m (2 H)	4	
IV	6·49 d	[a]	8·05 s	7·27−7·60 m (3 H) 7·87−8·18 m (2 H)	3·5	2·40 s (3 H, CH_3)
V	7·83 d	[a]	8·35 s	7·45−7·65 m (3 H) 8·00−8·27 m (2 H)	4	
VI	5·82 d	[a]	7·62 s	7·17−8·07 m (6 H)	4	3·15 s (6 H, CH_3)
VII	[a]	[a]	8·18 s	7·31−8·18 m (12 H)	3·5	
VIII	[a]	[a]	8·12 s	7·31−7·65 m (3 H) 7·92−8·10 m (3 H)	[b]	3·83 s (3 H, CH_3)
IX	[a]	[a]	8·65 s	7·22−7·60 m (3 H) 7·93−8·22 m (3 H)	[b]	
X	6·46 m	[a]	8·18 s	7·25−7·60 m (4 H) 7·87−8·18 m (3 H)	3·5	11·85−12·02 (1 H, NH)

[a] Overlapped by H-arom; [b] unreadable due to the overlap of H-arom.

TABLE III

^{13}C NMR chemical shift data (δ, ppm)

Compound	C-2	C-3′	C-3	C-4	C-5	C-6	C-6′	C-7	C-8	C-9	C-10	C-11	C-12	C-13	C-14
I	162·3	153·0	123·5	127·3	125·9	121·7	135·1	101·5	116·3	131·0	141·4	119·6	113·7	147·1	—
II	161·4	153·7	123·5	127·0	126·0	121·7	135·2	101·8	115·8	130·4	132·0	120·9	115·8	151·2	—
III	162·9	153·6	124·4	127·1	126·2	122·7	134·4	102·6	115·7	130·9	134·4	124·3	122·9	102·6	—
IV	162·8	153·7	123·2	126·7	125·5	121·5	134·9	99·2	116·6	131·4	148·0	121·8	110·7	158·9	14·2
V	162·3	152·9	123·2	127·2	126·5	121·4	134·6	104·4	115·2	132·1	146·2	122·5	120·3	157·7	—
VI	163·7	154·1	122·1	126·3	124·2	121·5	134·5	88·7	119·2	130·1	140·8	127·8	89·1	165·4	38·2
VII	161·0	153·7	123·9	127·2	126·5	121·8	135·4	106·5	115·6	134·5	138·9	118·6	118·1	152·8	152·6[a]
VIII	161·2	153·7	123·9	127·2	126·4	121·7	135·3	105·9	115·5	131·4	146·6	119·9	118·3	151·3	158·4[b]
IX	162·7	152·9	122·8	126·9	125·9	122·2	134·2	101·0	116·2	140·7	136·3	138·1	128·5	135·1	
X	162·9	153·0	123·5	126·8	125·4	121·6	134·6	95·8	119·1	135·5	127·2	127·1	112·2	122·7	

[a] 129·6 (*o*), 128·8 (*m*), 130·0 (*p*); [b] 52·5 (OCH_3).

techniques were employed. The *E*-geometry for these compounds was ascribed from the coupling constant values ^3J(C-8, H) 13·88 Hz and ^3J(C-2, H) 7·16 Hz (derivative *IX*).

Similar values of coupling constants were also found with other derivatives[11]. Electronic effect associated with variation of substituents at C-13 (position 5 of the five-membered heterocycle) and/or at the heteroatom itself (O, S, N) were not transmitted to the benzothiazole ring, as evidenced by the ^{13}C NMR chemical shift values. On the other hand, these effects were quite pronounced at C-7 thus indicating a considerable interaction of π-electrons of furan, thiophene and pyrrole with those of the polarized exocyclic double bond.

EXPERIMENTAL

2-Cyanomethylbenzothiazole was obtained by reacting malonodinitrile with 2-aminopheno in acetic acid acidified ethanol[12]. 3-(5-X-2-Furyl)-2-cyanoacrylonitriles were prepared from the corresponding aldehydes and malonodinitrile in ethanol under catalysis of sodium methoxylate or piperidine[13]. 3-(2-Pyrrolyl)-2-cyanoacrylonitrile was synthesized from pyrrole-2-carboxaldehyde and malonodinitrile in aqueous ethanol in the presence of glycine as catalyst[14].

1-(2-Benzothiazolyl)-1-cyano-2-heteroarylethylenes *I*—*X*

Method A: To 2-Cyanomethylbenzothiazole (1·74 g, 10 mmol) and heteroaromatic aldehyde (10 mmol) dissolved in hot ethanol (50 ml) 2 to 3 drops of sodium ethoxide were added and the mixture was stirred at room temperature for 2 h. Crystals precipitating after 16 h of standing were filtered off and recrystallized from a suitable solvent (Table I).

Method B: 2-Cyanomethylbenzothiazole (1·74 g, 10 mmol) and 3-(5-X-furyl)-, 3-(2-thienyl)- or 3-(2-pyrrolyl)-2-cyanoacrylonitrile (10 mmol) were refluxed in tetrahydrofuran (10 ml) for 6 h in the presence of some drops of triethylamine. The mixture was cooled and the separated precipitate was filtered off and crystallized.

Spectral Measurements

The UV spectra of methanolic solutions ($5 . 10^{-5}$ mol l^{-1}) were measured in 5 mm-cells with an M-40 (Zeiss, Jena) spectrophotometer. The ^{1}H NMR spectra of $(CD_3)_2SO$ solutions containing tetramethylsilane as an internal reference were recorded with a Tesla BS 487 C apparatus operating at 80 MHz. The ^{13}C NMR spectra were run in the same solvent at 28°C with a Varian XL-300 instrument operating at 18 MHz; the number of accumulations varied within 1 000 and 6 000 according to the solubility of samples.

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