

STEREOCHEMISTRY OF SOME SUBSTITUTED 2-FURYL-
AND 2-THIENYL ETHYLENE DERIVATIVES. ^1H NMR STUDY*

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Received October 2nd, 1981

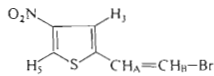
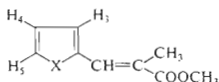
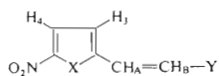
Stereochemistry of (*E*)- and (*Z*)-1-(5-nitro-2-furyl)-2-Y-ethylenes and 1-(5-nitro-2-thienyl)-2-Y-ethylenes (where $\text{Y}=\text{CH}_3\text{O}$, $4\text{-CH}_3\text{C}_6\text{H}_4\text{O}$, N_3 and Br) and of *E* and *Z* isomers of methyl 2-methyl-3-(2-furyl)propenoate and methyl 2-methyl-3-(2-thienyl)propenoate was studied by ^1H NMR spectroscopy. With 1-(5-nitro-2-furyl)-2-Y-ethylenes, it was found that the preferred conformation of the furyl substituent relative to the side chain double bond is *s-trans* in the *E* isomers and *s-cis* in the *Z* isomers. The *s-cis* conformation is prevailing in both isomers of methyl 2-methyl-3-(2-furyl)propenoate. The *E* and *Z* isomers of all studied thiophene derivatives exist in the *s-trans* conformation.

The study of stereochemistry of some furylethylene derivatives by ^1H NMR spectroscopy was subject of some previous studies of our group¹⁻⁵ and other authors⁶⁻¹⁰. Compounds of two types were studied: (*E*)- and (*Z*)-1-(5-nitro-2-furyl)-2-ethylenes *I-IV* and 1-(5-nitro-2-thienyl)-2-Y-ethylenes *V-VIII*; (*Z*)-1-(4-nitro-2-thienyl)-2-bromoethylene (*IX*) was used as a model compound in this series; methyl 2-methyl-3-(2-furyl)propenoate (*X*) and methyl 2-methyl-3-(2-thienyl)propenoate (*XI*). Since these compounds were prepared as the *E* and *Z* isomers which can exist as different conformers owing to the different orientation of the heterocyclic ring, it was possible to observe the relationships between the spectral parameters and the conformation of the 2-furyl- and 2-thienylethylene system, respectively. To determine the preferred conformation, the stereospecific long-range coupling $^5J_{\text{H,H}}$ between the olefinic proton H_A and the H_4 or H_5 proton of the heterocyclic ring, respectively^{9,10}, and the chemical shift of the H_3 proton of the heterocycle were used.

The isomers of compounds *I-IX* were distinguished using the magnitude of the vicinal coupling constant between the olefinic protons. Its value is larger for the *E*-isomers (12.3–14.0 Hz) than for the *Z*-isomers (6.7–8.5 Hz) see Table I. With furane derivatives *I-IV*, there is a large difference of the furane ring H_3 proton, chemical shift values ($\Delta\delta = 0.46\text{--}0.80$ ppm) in the corresponding *E*, *Z* pairs. The proton H_3 in the *Z*-isomers resonates in the lower field than in the *E*-isomers owing

* Part CLXIX in the series Furane Derivatives; Part CLXVIII: This Journal, 47, 3288 (1982).

to the deshielding effect of the Y-substituent on the double bond. Chemical shift of the H_A proton is practically unaffected by the position of the Y-substituent. That indicates a preferred *s-cis* conformation of *Z*-isomers of furane derivatives, in agreement with the observed stereospecific long-range coupling constant ${}^5J(H_4, H_A)$. The magnitude of this coupling is 0.6–0.7 Hz in the *s-cis* conformation of the *Z*-isomers, in which it is enhanced owing to the five bond *W* arrangement. On the contrary, no such a coupling was observed with *E*-isomers what confirmed the preferred *s-trans* conformation.



- I, X = O, Y = CH₃O
 II, X = O, Y = 4-CH₃C₆H₄O
 III, X = O, Y = N₃
 IV, X = O, Y = Br
 V, X = S, Y = CH₃O
 VI, X = S, Y = 4-CH₃C₆H₄O
 VII, X = S, Y = N₃
 VIII, X = S, Y = Br

- X, X = O
 XI, X = S

IX

With thiophene derivatives *V–VII*, there is no substantial difference in the chemical shift of the H_3 proton in the corresponding isomeric pairs and the coupling constant ${}^5J(H_4, H_A)$ is nearly zero. That indicates the *s-trans* conformation of both *E* and *Z* isomers. This conclusion is supported by comparison of the NMR spectra of *VIII* and *IX*. The compound *VIII* was obtained as the *Z*-isomer. To compare the spectral properties, (*Z*)-1-(4-nitro-2-thienyl)-2-bromoethylene (*IX*) in which the coupling between the ethylene proton H_A and the thiophene ring proton H_5 is observable, was used as a model compound. No coupling between H_4 and H_A was observed in the 1H NMR spectrum of *VIII* whilst in *IX* the coupling constant $J(H_5, H_A) = 0.6$ Hz was found what confirmed the preferred *s-trans* conformation.

The methyl esters of 2-methyl-3-(2-furyl)propenoic acid (*X*) and 2-methyl-3-(2-thienyl)propenoic acid (*XI*) were prepared as the *E*-isomers. The corresponding *Z*-isomers were obtained by their photoisomerization. The 1H NMR data are given in Table II. The configuration of substituents on the double bond in the compound *X* was determined by comparison of the chemical shifts of the olefinic proton measured and calculated using the additive increments¹¹. The comparison of spectral parameters of the corresponding isomeric pairs confirmed the *E* configuration of the prepared compounds *X* and *XI* in which the olefinic proton H_A is more deshielded in the *E*-isomer than in the *Z* one ($\Delta\delta = 0.91$ and 0.93 ppm, respectively) as a result

TABLE I
 ^1H NMR data (δ , ppm; J , Hz) of compounds I–IX

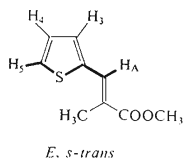
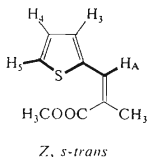
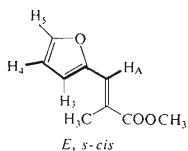
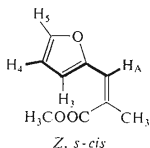
Compound	Isomer	H_3^a	H_4^a	H_A	H_B	$J_{A,B}$
I	Z	6.70	7.36	5.41	6.49	6.7
	E	6.24	7.30	5.68	7.40	12.8
II	Z	6.88	7.32	5.68	6.87	6.7
	E	6.28	7.26	6.01	7.52	12.4
III	Z	6.90	7.34	5.73	6.70	8.4
	E	6.37	7.30	6.07	7.14	13.5
IV	Z	7.31	7.40	7.14	6.81	8.5
	E	6.51	7.31	7.20	6.96	14.0
V	Z	6.78	7.77	5.65	6.41	6.2
	E	6.70	7.74	6.88	7.18	12.7
VI	Z	6.80	7.79	5.93	6.82	6.3
	E	6.75	7.74	6.24	7.30	12.3
VII	Z	6.92	7.79	5.94	6.60	7.8
	E	6.84	7.77	6.29	6.83	13.7
VIII	Z	7.16	7.86	7.31	6.57	8.0
IX ^b	Z	7.74	—	7.26	6.55	8.0

^a $J_{3,4} = 3.9$ (for I–IV), $J_{3,4} = 4.3$ (for V–VIII); ^b $\delta\text{H}_5 = 8.26$, $J_{3,5} = 1.2$, $J(\text{H}_A, \text{H}_5) = 0.6$.

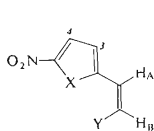
TABLE II
 ^1H NMR (δ , ppm; J , Hz) of methyl 2-methyl-3-(2-furyl) propenoate (X) and methyl 2-methyl-3-(2-thienyl)propenoate XI

Compound	Isomer	H_3	H_4	H_5	H_A	CH_3	OCH_3
X ^a	Z	6.95	6.38	7.36	6.52	2.00	3.77
	E	6.57	6.45	7.50	7.43	2.19	3.77
XI ^b	Z	7.15	6.88	7.28	6.87	2.00	3.68
	E	7.16	6.95	7.39	7.80	2.14	3.68

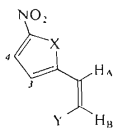
^a $J_{3,4} = 3.5$, $J_{4,5} = 1.6$, $J(\text{H}_A, \text{CH}_3) = 1.2$ (for E and Z); ^b $J_{3,4} = 3.4$, $J_{4,5} = 5.0$, $J(\text{H}_A, \text{CH}_3) = 1.0$ (for E = Z).



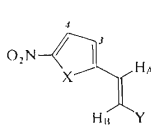
of the methoxycarbonyl group anisotropy¹². The preferred conformation of the furane and thiophene substituents was determined analogously to the compounds *I–VIII* using the long-range coupling constants between H_A and H_4 and between H_A and H_5 , respectively (methyl decoupled spectra). With methyl (*E*)-2-methyl-3-(2-furyl)propanoate (*X*), the coupling constant $J(H_4, H_A) = 0.5$ Hz was found; with its *Z* isomer the value was 0.6 Hz; no coupling between H_A and H_5 was observed. The proton H_3 in the *Z* isomer is deshielded owing to the COOCH_3 group anisotropy of $\Delta\delta = 0.38$ ppm. These results show that the *s-cis* conformation is prevailing in both isomers. The conformation *s-cis* in the *E* isomer is also confirmed by the results of the NOE experiment in which the irradiation of the double bond CH_3 protons causes a 24% increase in intensity of the H_3 signal. The coupling constant $J(H_5, H_A) = 0.7$ Hz in both *E* and *Z* isomers of methyl 2-methyl-3-(2-thienyl)propanoate (*XI*); no coupling between H_4 and H_A was observed. The chemical shift of H_3 is not affected by the configuration of substituents on the double bond. No intensity enhancement of the H_3 proton signal was observed in an analogous NOE experiment. These results confirm the *s-trans* conformation in *E* and *Z* isomers of the compound *XI*.



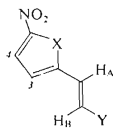
Z, s-trans
 $X = \text{S}$



Z, s-cis
 $X = \text{O}$



E, s-trans
 $X = \text{O, S}$



E, s-cis

The preferred *s-trans* conformation was found in all studied thiophene derivatives. Unlike to the furane nucleus, the change of the double bond configuration does not affect the orientation of the thiohene ring. Similar differences in the conformational properties of furane and thiophene were also found in other furyl- and thienylethylene derivatives^{6,13}. The existence of *s-cis* conformation in *Z* isomers of furylethylene derivatives can be explained by a decrease in stability of the *s-trans* conformation resulting from the electrostatic repulsion between the heterocyclic oxygen and the double bond substituent.

EXPERIMENTAL

¹H NMR spectra were measured at 80 MHz on a Tesla BS 487 C spectrometer in deuteriochloroform at 25°C using tetramethylsilane as an internal standard. The signals were assigned by the INDOR technique, the long-range couplings were proved by decoupling experiments.

(4-Methylphenyl)-5-nitro-2-furylvinyl ether⁴ (*II*), 5-nitro-2-furylvinyl azide¹⁴ (*III*), 5-nitro-2-furylvinyl bromide¹⁵ (*IV*), (4-methylphenyl)-5-nitro-2-thienylvinyl ether¹⁶ (*VI*), 5-nitro-2-thienylvinyl azide¹⁶ (*VII*), 5-nitro-2-thienylvinyl bromide¹⁶ (*VIII*), methyl 2-methyl-3-(2-furyl)propenoate¹⁷ (*X*) and methyl 2-methyl-3-(2-thienyl)propenoate¹⁸ (*XI*) were described in our previous papers. 4-Nitro-2-thienyl vinyl bromide (*IX*) was obtained in the 10% yield as a side product in the preparation of *VIII* according to the ref.¹⁶.

Methyl 5-nitro-2-furylvinyl ether (*I*): The solution of 5-nitro-2-furylvinyltrimethylammonium bromide (5.5 g, 0.02 mol) in methanol (20 ml) was mixed with the solution of CH₃ONa (1.1 g) in methanol (10 ml) and stirred 1 h. The solvent was removed and the residue was purified by chromatography on silica gel (150–250 mesh) using benzene as a mobile phase. Crystalline product (1 g, 27%), containing the mixture of *Z* and *E* isomers in the ratio 3 : 2, was obtained. The isomers were separated by fractional crystallization from hexane. The *Z* isomer has m.p. 122°C, the *E* isomer has m.p. 45–46°C.

Methyl 5-nitro-2-thienylvinyl ether (*V*) was prepared from 5-nitro-2-thienylvinyltrimethylammonium bromide by a process analogous to that used for *I*.

Isomerization of esters X and XI was achieved by irradiation of the tetrachloromethane solution of the compound by a medium-pressure mercury lamp Tesla RVK 125. The solvent was removed and so obtained mixture of *E* and *Z* isomers was studied by ¹H NMR spectroscopy.

REFERENCES

1. Černayová M., Kováč J., Dandárová M., Hasová B., Palovčík R.: This Journal *41*, 764 (1976).
2. Štetinová J., Kováč J., Surá J., Dandárová M.: This Journal *42*, 2201 (1977).
3. Považanec F., Kováč J., Dandárová M.: Chem. Zvesti *32*, 397 (1978).
4. Dandárová M., Kováč J., Végh D.: This Journal *45*, 3557 (1980).
5. Kutschy P., Kristian P., Dandárová M., Kováč J.: This Journal *46*, 1160 (1981).
6. Fisichella S., Miner G., Scarlata G., Sciotto D.: Tetrahedron *31*, 2445 (1975).
7. Bottino F. A., Miner G., Sciotto D.: Tetrahedron *34*, 1557 (1978).
8. Haslinger E., Wolschann P.: Org. Magn. Resonance *9*, 1 (1977).
9. Huckerby T. N.: Tetrahedron Lett. *1971*, 353.
10. Parr W. J. E., Wasylishen R. E., Schaefer T.: Can. J. Chem. *54*, 3216 (1976).

11. Matter U. E., Pascual C., Pretsch E., Pross A., Simon W., Sternhell S.: *Tetrahedron* **25**, 691 (1969).
12. Jackmann L. M., Willey R. M.: *J. Chem. Soc.* **1960**, 2886.
13. Arcoria A., Bottino F. A., Sciotto D.: *J. Heterocycl. Chem.* **14**, 1353 (1977).
14. Végh D., Kováč J., Považanec F.: *This Journal* **43**, 3404 (1978).
15. Végh D., Kováč J., Hasová B.: *This Journal* **41**, 614 (1976).
16. Végh D., Kováč J., Dandárová M.: *Tetrahedron Lett.* **1980**, 969.
17. Žvak V., Kováč J., Križ M.: *This Journal* **45**, 906 (1980).
18. Žvak V., Kováč J., Dandárová M., Križ M., Gracza T.: *This Journal*, in press.

Translated by P. Sedmera.