

## Meisenheimer-type Adducts from 2-Nitrothiophene and 2-Nitrofuran

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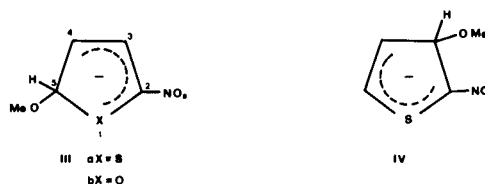
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Sir:

Although most studies on the Meisenheimer-type adducts from heteroaromatic 5-membered rings have concerned the reaction of thiophene derivatives with methoxide anion (1-3), furan derivatives are of no less importance in providing considerable insight in the field, especially in view of the different thermodynamic stabilities of the parent ring systems. We wish to report on the interaction of 2-nitrothiophene (I) and 2-nitrofuran (II) with methoxide anion. This is the first study of this kind concerning a furan system.

Nmr data are collected in the Table for I and II, and for the species formed upon addition of one equivalent of sodium methoxide (nearly 4 M in methanol) to DMSO- $d_6$  and perdeuteriomethanol solutions of I and II. The nmr spectrum for the product of the reaction between I and methoxide ion in DMSO- $d_6$  is identical, in the low-field region, to that of the DMSO- $d_6$  solution of a deep-red solid, isolated after evaporation of the solvent from a warm methanolic solution containing equivalent amounts of the same reagents. In this case it was also possible to observe the singlet of a methoxy group at  $\tau$  6.9. Under similar conditions Steinkopf (4) reported the isolation of a 1:1 adduct, of uncertain structure (5), between I and potassium methoxide.



The reactions are completely shifted towards the formation of the products, except in the case of the reaction of I in perdeuteriomethanol, nearly 75% of I being still present at the equilibrium. In each case the ring protons of the products give rise to nmr spectra significantly shifted to higher field than the signals of the substrates, indicating the probable formation of negatively charged species. In the present case the formation of ring-opening products, observed in the reaction of I with amines (6) and of II with methoxide ion in refluxing methanol (7), may be ruled out on the basis of the nmr spectra of the products and, more particularly, of the absence of the strongly coupled signals, typical of a conjugate diene, observed in the products of I with amines (6). The nmr spectra are thus consistent with the formation of Meisenheimer-type adducts.

TABLE (a)

System	Solvent	Chemical shift ( $\tau$ ) (b)			Coupling constant (c)		
		H-3	H-4	H-5	$J_{34}$	$J_{35}$	$J_{45}$
I (d,e)	DMSO- $d_6$	1.91	2.80	2.02	4	1.5	5.5
	CD <sub>3</sub> OD	2.07	2.92	2.23	4	1.5	5.5
II (f)	DMSO- $d_6$	2.42	3.20	2.02	4	1	2
	CD <sub>3</sub> OD	2.68	3.35	2.36	4	1	2
I+CH <sub>3</sub> O <sup>-</sup> (f)	DMSO- $d_6$	3.28	4.45	3.92	6	0	3
	CD <sub>3</sub> OD	3.23	4.08	3.83	6	0	3
II+CH <sub>3</sub> O <sup>-</sup>	DMSO- $d_6$ (f)	3.28	4.28	3.99	6	0	2
	CD <sub>3</sub> OD (e)	3.33	4.01	3.98	5	0	2

(a) JEOL C-60 Instrument, solutions 0.3-0.4 M, sweep width 540 Hz. Integration of the signals was satisfactory, except in the case of the reaction of I in perdeuteriomethanol owing to overlapping of ring-proton 4 with the solvent. Slow exchange (see Text) and/or decomposition may follow the formation of the adducts. (b) ppm ( $\pm 0.03$ ), downfield from DSS as internal reference. (c) Hz ( $\pm 0.5$ ). (d) Assignment based upon Ref. 6. (e) ABX system. (f) AMX system.

In the case of the reaction of I in perdeuteriomethanol, the choice between the possible structures IIIa and IV is based upon the fact that in the reaction conditions both I and the corresponding adduct slowly undergo an isotopic exchange. After 18 hours, the nmr spectrum of I shows only two doublets of the same intensity at  $\tau$  2.1 and 2.9 ( $J = 4$  Hz). The position of the signals (8) and the coupling constant indicate that exchange occurs at position 5. As a consequence of the equilibrium existing between I and the adduct, the latter appears to undergo an isotopic exchange reaction at the same position. Accordingly, its nmr spectrum shows two doublets, corresponding to positions 3 and 4 of the adduct, respectively, at  $\tau$  3.2 and 4.1 ( $J = 6$  Hz). Examination of the chemical shift values for I and the corresponding adduct shows that, upon reaction with methoxide ion, the ring proton at position 5 of the substrate undergoes the largest upfield shift. This fact and the marked decrease observed for the  $J_{35}$  and  $J_{45}$  values in going from I to the adduct indicate that the carbon atom at position 5 changes its hybridization state from  $sp^2$  to  $sp^3$ . Therefore, the adduct may be assigned structure IIIa. This finding is in accordance with the observed tendency of thiophene derivatives to undergo preferably nucleophilic addition at an  $\alpha$  position (1-3).

Strong similarities in the chemical shift and coupling constant values may be pointed out between the species formed from I and II. In the reaction of II in perdeuteriomethanol no exchange reaction was observed. However, the analogies of the nmr spectra suggest that the reactions of I and II follow initially a common pattern, yielding adducts IIIa and IIIb, respectively.

In DMSO- $d_6$  a difference in the tendency of I and II to add methoxide ion cannot be recognized. The strong stabilization effect of the solvent on the charge-dispersed anionic systems is responsible for this levelling effect. However, examination of the nmr spectra of the systems

at equilibrium in methanol shows that the equilibrium constant for the formation of adduct IIIb is larger than the related value for the formation of IIIa. Preliminary spectrophotometric data indicate that the equilibrium constant ratio in methanol, at 25°, is about 25.

It has been pointed out (1a) that the energy content of the substrate may play a significant role in determining the stability of Meisenheimer-type adducts. Thus, the present result, even if it does not rule out a specific role of the sulfur atom, indicates that the lower aromaticity of the furan ring may account for the difference between the reactivity of I and II toward methoxide ion.

Further work on the reactivity of furan derivatives is in progress.

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#### REFERENCES

- (1) G. Doddi, G. Illuminati, and F. Stegel, (a) *J. Org. Chem.*, **36**, 1918 (1971); (b) *Chem. Commun.*, 1143 (1972); (c) *Tetrahedron Letters*, 3221 (1973).
- (2) D. Spinelli, V. Armanino, and A. Corrao, *J. Heterocyclic Chem.*, **7**, 1441 (1970).
- (3a) C. Paulmier, M. P. Simonnin, A. P. Chatrousse, and F. Terrier, *Tetrahedron Letters*, 1123 (1973); (b) M. P. Simonnin, F. Terrier, and C. Paulmier, *ibid.*, 2803 (1973).
- (4) W. Steinkopf, *Ann. Chem.*, **513**, 285 (1934).
- (5) W. Steinkopf, "Die Chemie des Thiophens", T. Steinkopff, Dresden, 1941, p. 227.
- (6) G. Guanti, C. Dell'Erba, and G. Leandri, *Chem. Commun.*, 1060 (1972).
- (7) T. Irie, E. Kurosawa, and T. Hanada, *J. Fac. Sci., Hokkaido Univ.*, III, **5**, 6 (1957); through *Chem. Abstr.*, **52**, 16328 (1958).
- (8) S. Gronowitz and R. A. Hoffman, *Arkiv Kemi*, **13**, 279 (1958).