Nitration of *trans*-2-Styrylthiophene

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The nitration of *trans*-2-styrylthiophene in carbon tetrachloride, nitroethane and acetic anhydride has been investigated.

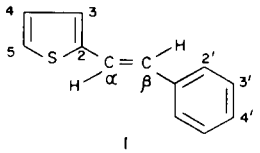
The nitration products were: β-nitro-2-styrylthiophene as the main product with 3-nitro-2-styrylthiophene and the 5-nitro isomer in smaller amounts. They were identified by the chromatographic and spectroscopic (uv and nmr) comparison with the reference compounds.

The isomer percentages, determined by glc, were unchanged under different nitration conditions (time, temperature and molar ratio), but were dependent on the solvent used.

Previously the nitration and spectroscopic behaviour of 2-benzylthiophene (1) and 2-thienyl phenyl ketone had been investigated (2) to determine the relative reactivity of the two aromatic ring systems connected by the insulating groups, CH_2 (activating) and CO (deactivating).

Experimental results have also shown that the heterocyclic ring system is more reactive than the phenyl group as shown by the nitration of 2-phenylthiophene (3).

It is the purpose of this paper to examine the nitration of *trans*-2-styrylthiophene (I) in order to verify the reactivity of the two ring systems joined by a vinyl group, a conjugation conductor.



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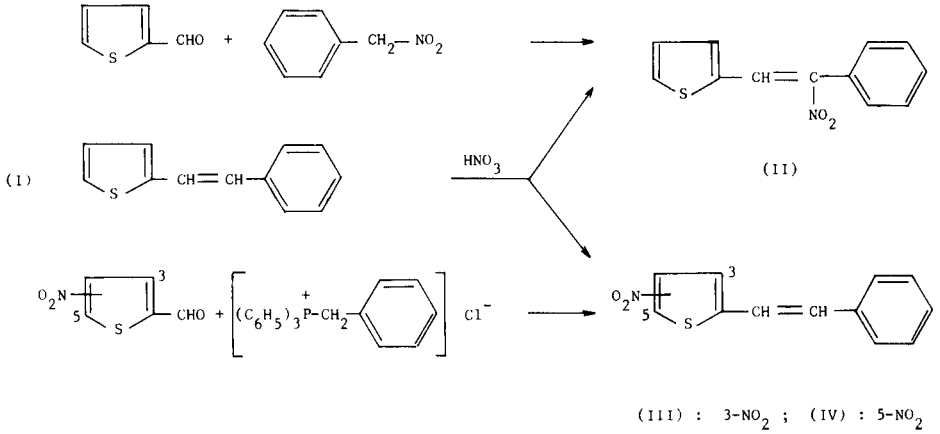
In the analogous *trans*-stilbene the more reactive positions are shifted from the aromatic nucleus to the olefinic double bond. In fact, the nitration of *trans*-stilbene in acetic anhydride (4) gave mainly the addition product (nitroacetate) and only a small quantity of product with substitution on the aromatic ring.

However, in compound I, the presence of the thiophene ring system modifies the reactivity toward electrophilic agents; for instance, the formylation and acetylation yielded 5-substituted derivatives (5). Also the bromination with NBS gave the 5-substituted product (6). Nitration of *trans*-2-styrylthiophene in carbon tetrachloride, nitroethane or acetic anhydride solution, gave β-nitro-2-styrylthiophene (II) as the main product together with 3-nitro-2-styrylthiophene (III) and the 5-nitro isomer (IV), the former being present in smaller amounts.

Preliminary experiments, carried out in the range 0-30° with a molar ratio of 2-styrylthiophene/nitric acid 1:1

SCHEME 1



(III) : $3\text{-}NO_2$; (IV) : $5\text{-}NO_2$

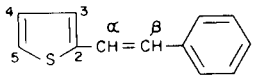
TABLE I

Nitration of *trans*-2-Styrylthiophene

Solvent	Conv. %	β-NO_2 %	3-NO_2 %	5-NO_2 %	$\frac{\beta\text{-}NO_2}{3\text{-}NO_2 + 5\text{-}NO_2}$	$\frac{5\text{-}NO_2}{3\text{-}NO_2}$
CCl_4	65	78	4	18	3.5	4.5
C_2H_5-NO_2	100	71	7	22	2.4	3.1
Ac_2O	100	56	15	29	1.3	1.9

TABLE II

Nmr Data for the Nitration Products of *trans*-2-Styrylthiophene



	Chemical Shifts δ (ppm)						Coupling Constants (cps)
	H-3	H-4	H-5	H-phenyl	H-α	H-β	
I (a)	←			(6.90-7.50) (m)	→	6.88 (d)	$J_{\alpha,\beta}$ = 16.3
II		7.00 (q) ←		(7.23-7.67) (m)	→ 8.52 (s)	-----	$J_{3,4}$ = 4.0; $J_{4,5}$ = 5.0
III	←			(6.90-7.60) (m)	→ 7.78 (d)	6.93 (d)	$J_{\alpha,\beta}$ = 16.2
IV	6.98 (d)	7.80 (d)	-----	(7.20-7.60) (m)		7.10 (s)	$J_{3,4}$ = 4.25

(a) The spectrum is coincident to that reported by R. M. Acheson and D. R. Harrison, *J. Chem. Soc.* (C), 1764 (1970). s = singlet; d = doublet; q = quartet; m = multiplet.

TABLE III

Glc Data for the Nitration Products of *trans*-2-Styrylthiophene

Compound	Retention time (seconds)	Correction factor
I	108	0.96
II	225	1.00
III	347	1.02
IV	421	1.04

and 1:2, resulted only in a variation of the conversion values, while the isomeric ratio was substantially unchanged. Therefore 2-styrylthiophene was nitrated at 25° with a molar ratio 1:2 for 30 minutes yielding mononitro derivatives and small amounts (3-5%) of dinitro derivatives.

The experimental results are summarized in Table I.

The nitration products, identified by tlc by comparison with the reference compounds (Fig. 1), prepared as shown in scheme I, were determined quantitatively by glc and, also, were separated from the reaction mixture by fractional precipitation and column chromatography. Uv spectra (Fig. 2) and nmr data (Table II) offered additional support with regard to their identity.

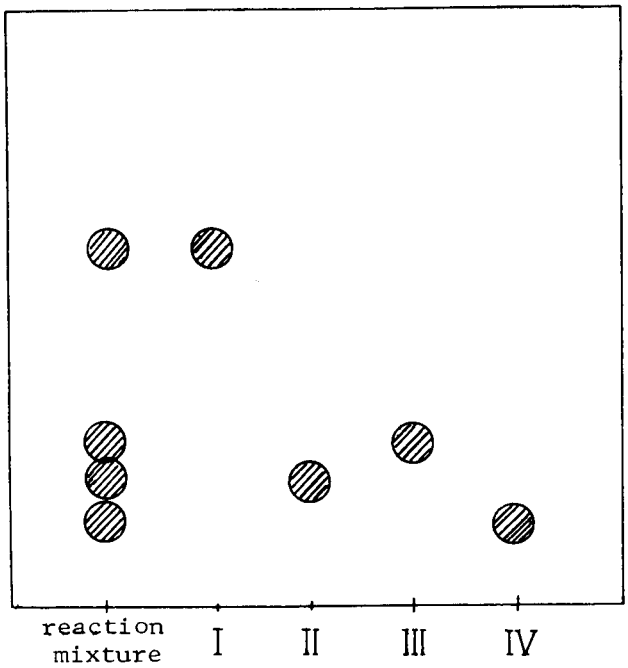


Fig. 1. Thin-layer chromatogram of the nitration products of *trans*-2-styrylthiophene.

The higher percentage of β-nitro-2-styrylthiophene to nitrothiophenes (III and IV) shows that major reactivity

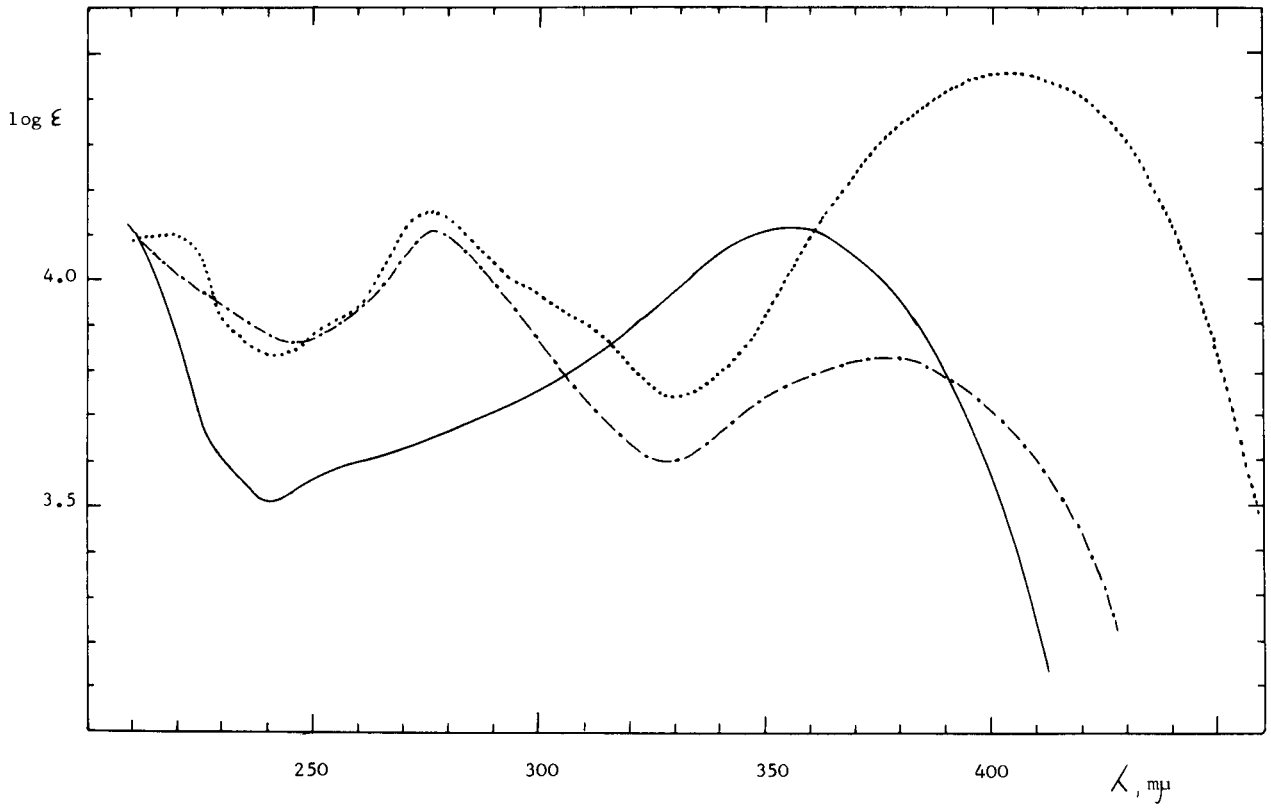


Fig. 2. Uv spectra in 95% ethanol: β-nitro-2-styrylthiophene ———; 3-nitro-2-styrylthiophene —·—·—·—; 5-nitro-2-styrylthiophene . . . . . .

toward nitration occurs at the β-carbon of the vinyl group, due to olefinic bond polarization, Th-$\overset{+}{C}$H-$\overset{-}{C}$H-Ph. The percentages of mononitro compounds is influenced by the nitrating agent, as shown by the ratio β-nitro/3-nitro + 5-nitro.

The lowest value of this ratio occurred in acetic anhydride which is a suitable solvent for substitution in the aromatic nucleus and, which also modifies the 5-nitro- and 3-nitro-2-styrylthiophene percentages. In fact, the ratio 5-nitro/3-nitro from 4.5 in carbon tetrachloride and 3.1 in nitroethane is lowered to 1.9 in acetic anhydride, as in the 2-phenylthiophene nitration where the ratio is 1.5 (3).

EXPERIMENTAL

trans-2-Styrylthiophene Preparation (I).

To a stirred solution of 38.9 g. (0.1 mole) of benzyltriphenylphosphonium chloride (7) in 300 ml. of 95% ethanol and 11.2 g. (0.1 mole) of 2-thiophenaldehyde (8) were added dropwise 0.1 mole of sodium ethylate in ethanol. After standing 24 hours, the white solid which separated was collected and washed with water. It was crystallized several times from ethanol to remove the *cis* isomer. There was obtained 13.9 g. (yield 75%) m.p. 112°.

For previous syntheses and melting points see reference 9.

trans-2-Styrylthiophene Nitration.

To 9.3 g. (0.05 mole) of *trans*-2-styrylthiophene in carbon tetrachloride (100 ml.), nitroethane (100 ml.) or acetic anhydride (250 ml.), were added at 25°, 6.3 g. (0.1 mole) of anhydrous distilled nitric acid in carbon tetrachloride, nitroethane or acetic anhydride (50 ml.). The solution was stirred for 30 minutes and then poured onto crushed ice, neutralized with sodium carbonate and extracted several times with ether. The extract was dried, filtered and evaporated and then analyzed by tlc.

The thin layer chromatogram (silica gel, carbon tetrachloride as eluent) showed four spots (uv light: 254 mμ) identified by comparison with the reference compounds (Fig. 1). The nitration products and the yields were determined by glc using a Model C Carlo Erba gas chromatograph on a 80 cm column packed with methyl silicone polymer SE 30 (25%) on chromosorb P (30-60 mesh) at 220° with helium as carrier (6 l./hour).

The quantitative analysis of the isomer percentages was carried out by the internal normalization method after determination of the area correction factors on known standard mixtures. In Table III the retention times and area correction factors for each standard are reported.

Separation of Nitration Products.

The nitration mixture extract was dissolved in hot carbon tetrachloride and, after partial evaporation, a red solid separated. Crystallization from ethanol gave orange plates, m.p. 137°, identified as 5-nitro-2-styrylthiophene (IV).

From the cold filtrate, a yellow solid separated which was

crystallized from absolute ethanol, m.p. 126-127°, it was identified as β-nitro-2-styrylthiophene (II).

After the β-nitro (II) separation, the residue was passed into a silica gel column (carbon tetrachloride as eluent); from the first fractions, after eluent evaporation, a solid separated. Recrystallization from light ligroin gave yellow plates, m.p. 88°, identified as 3-nitro-2-styrylthiophene (III).

β-Nitro-2-styrylthiophene (II).

To a solution of 13.7 g. (0.1 mole) of phenylnitromethane in 25 ml. of glacial acetic acid, was added 16 g. (0.1 mole) of the Schiff's base, obtained by condensation of 2-thiophenaldehyde and *n*-butylamine (10). The product was crystallized from ethanol, m.p. 126-127°; uv spectra: λ infl. 260 mμ (log ε = 3.60), λ max 357 mμ (log ε = 4.12).

trans-3-Nitro-2-styrylthiophene (III).

A solution of sodium ethylate in ethanol was added dropwise to a stirred solution of 7.78 g. (0.02 mole) of benzyltriphenylphosphonium chloride in 60 ml. of ethanol and 3.14 g. (0.02 mole) of 3-nitro-2-thiophenaldehyde, obtained by bromination (NBS) of 2-methyl-3-nitrothiophene followed by hydrolysis of the dibromo derivative (11). After standing 24 hours, the solid which separated was collected and washed several times with water. The crude product (1.17 g., 25%) when crystallized from light ligroin gave yellow plates, m.p. 88°, which was in accord with the product obtained by decarboxylation of 2-styryl-3-nitrothiophene-5-carboxylic acid (12); uv spectra: λ max = 277 mμ (log ε = 4.11), 376 mμ (log ε = 3.83).

Anal. Calcd. for $C_{12}H_9NO_2S$: C, 62.32; H, 3.92; N, 6.06. Found: C, 62.70; H, 3.98; N, 6.14.

trans-5-Nitro-2-styrylthiophene (IV).

Compound IV was prepared by the condensation of 3.14 g. (0.02 mole) of 5-nitro-2-thiophenaldehyde (13) and 7.78 g. (0.02 mole) of benzyltriphenylphosphonium chloride in the same manner as for the 3-nitro isomer (III). The crude product (2.30 g., 50%) was crystallized from ethanol to give orange plates, m.p. 137-138°; uv spectra: λ max = 276 mμ (log ε = 4.15), 405 mμ (log ε = 4.46).

Anal. Calcd. for $C_{12}H_9NO_2S$: C, 62.32; H, 3.92; N, 6.06. Found: C, 62.45; H, 3.87; N, 6.18.

The uv spectra were obtained with a Hitachi-Perkin Elmer Model EPS-3T spectrometer in ethanol solutions (1×10^{-5} mole/l.). Nmr spectra were recorded on a Varian A-60D spectrometer in deuteriochloroform with TMS as internal standard.

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