Synthesis of functionalised polythiophenes and (2-thienylcarbonyl)pyrroles *via* conjugate addition of (2-thienylcarbonyl)thioacetanilides to nitroakenes

J. Chem. Research (S), 2003, 51-53
J. Chem. Research (M), 2003, 0201–0209

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A convenient method is described for the synthesis of functionalised polythiophenes (**6a**-**s**) by treatment of (2-thienylcarbonyl)thioacetanilides with β-nitrostyrenes. Transformations of title products into pyrroles under acidic conditions are also discussed.

Keywords: thioacetanilides, β-nitrostyrenes, polythiophenes, thiophenes, pyrroles

Recently we have described an efficient approach to the construction of the thiophene ring system *via* tandem conjugate addition and cyclisation of (2-benzoyl)thioacetanilides and nitroalkenes.[5-7] The efficiency of this route prompted us extend this methodology to the synthesis of compounds containing two and three thiophene units. Various thiophene derivatives might be of general use in biological experiments, *e.g.* some polythiophenes are applied as fluorescent labels replacing the DNA base.[4] Our approach to the synthesis of the target molecules consisted in reaction of the substrates possessing at least one thiophene ring: starting materials were 2-(2-thienylcarbonyl)thioacetanilides **1**.

Reaction of **1** with (*E*)-β-nitrostyrenes **2** carried out in ethanol in the presence of piperidine afforded products **6** in good yield (60–90 %) (Scheme 1). The reaction of **1a** with nitrostyrene **2** yielding **6a** was representative and allowed the establishing of the structure of all synthesised compounds. The MS molecular mass determination of **6a** (*m/z* 392) indicated that the addition of **1a** to **2** is followed by the elimination of a water molecule. The most characteristic spectral features in the IR spectrum of **6a** were the presence of a broad band of the oxime hydroxyl group at 3160 cm^{-1} and the band of medium intensity at 1630 cm^{-1} (C=C) and a stronger one at 1570 cm^{-1} (C=N). The ^1H NMR spectrum of **6a** displayed one singlet at δ = 5.64 ppm for CH proton at C-4 of the formed thiophene skeleton. The GHMQC spectrum of **6a** indicated that it is bonded to carbon atom C-4 (53.26 ppm). Two singlets at δ = 7.49 ppm and δ = 13.57 ppm are assigned to two protons of the hydroxyl groups. The first one is assigned to the proton of the hydroxyl group of oxime function and the second one, shifted to the higher frequency, originates from the enolic proton of thienylcarbonyl moiety. Thus the molecule of **6a** in $CDCl_3$ solution exists in keto-enol equilibrium, which is entirely shifted towards the enolic form. The existence of β-keto-enamino form was supported the MS spectrum, which revealed intensive (100%) ions at *m/z* 111 assigned to thienylcarbonyl group. Both forms are stabilised by a H-bonded cyclic structure.[6] The proposed mechanism of formation of compounds **6** is outlined in Scheme 1.

To construct the molecules containing three thiophene units, 1-nitro-2-(2-thienyl)ethene **2** was applied in reaction with thioanilides **1f**,**l**,**s**. The compounds obtained (**6f,l,s**) revealed similar spectral features to those synthesised from **1** and β-nitrostyrenes **2**.

Compounds **6** are sensitive towards acidic reagents. Treatment of **6** with dilute hydrochloric acid in ethanolic solution caused their fast decomposition. Only in the case of **6a** we did manage to isolate an intensely yellow compound **7a** in 26 % yield. IR, ^1H, ^{13}C NMR and mass spectra allowed the establishment of its structure as a pyrrole derivative. Its IR spectrum revealed bands at 3490 cm^{-1} (OH) and 1750 cm^{-1} (C=O). The ^1H NMR spectrum displayed two singlets at δ = 4.91 ppm (CH) and δ = 14.74 ppm (OH), and multiplet of aromatic protons in the range 6.98–7.54 ppm. The ^{13}C NMR spectrum revealed two characteristic signals at δ = 197 ppm and 163 ppm attributed to thiocarbonyl and carbonyl groups. These data, and a molecular mass determination (*m/z* 377), indicated that compound **7a** resulted from the hydrolysis of the oxime function to a carbonyl and ring transformation of the imino-thiophene moiety to thioxopyrrole.

Treatment of **6a,m,s** with a boiling solution of acetic acid and acetic anhydride (1 : 1) furnished a deep brown mixture. Work up of this mixture with water and chromatographic purification yielded two groups of products, **9a,m,s** and **10a,m,s** respectively.

The major products **9a,m,s** (50-55 %) were identified as acetyl derivatives of the oxime nitrogen atom. The IR spectrum of **9a** displayed two strong bands of carbonyl groups at 1640 cm^{-1} and 1690 cm^{-1}. The ^1H NMR spectrum revealed only a singlet at δ = 2.34 ppm of three protons of acetyl group and the multiplet of aromatic protons in the range 7.0–7.7 ppm. These spectral data, combined with molecular mass determination (**9a,** *m/z* 416) indicated that the reaction of **6** with acetic acid and acetic anhydride involved preliminary dehydration of **6** followed by acylation.

The minor products **10a,m,s** (15–20 %) were identified as pyrrole derivatives. The IR spectrum of **10a** displayed two bands of carbonyl groups at 1725 and 1630 cm^{-1}. The ^1H NMR spectrum revealed the multiplet of aromatic protons at δ = 7.0–7.8 ppm, whereas the ^{13}C NMR spectrum showed three signals in the range of carbonyl and thiocarbonyl carbon resonance at δ = 196, 183 and 171 ppm. The first signal is attributed to the C=S carbon atom, the second to the C=O carbon of the thienylcarbonyl moiety and the third to the amide carbonyl. These spectral data, combined with MS molecular mass determination, indicated that the conversion of **6** involves dehydration, the hydrolysis of the imine group to carbonyl, followed by ring transformation of arylimino-thiophene into thioxopyrrole **10**. It is worth noting that the two groups of compounds **9** and **10** exhibit different colours. Compounds **9** are deep red, whereas compounds **10** are intense green or brown-green. The formation of compounds **7, 9** and **10** may be rationalised by the mechanism proposed in Scheme 2.

In summary, we present here an efficient one-pot synthesis of compounds possessing two and three thiophene units. We also demonstrate their transformation into polyfunctionalised pyrroles. The ready availability of the reagents, the fair to good yields of products, and the ease of work-up, make this method a very useful one. Some of the compounds obtained may be interesting for biological experiments.

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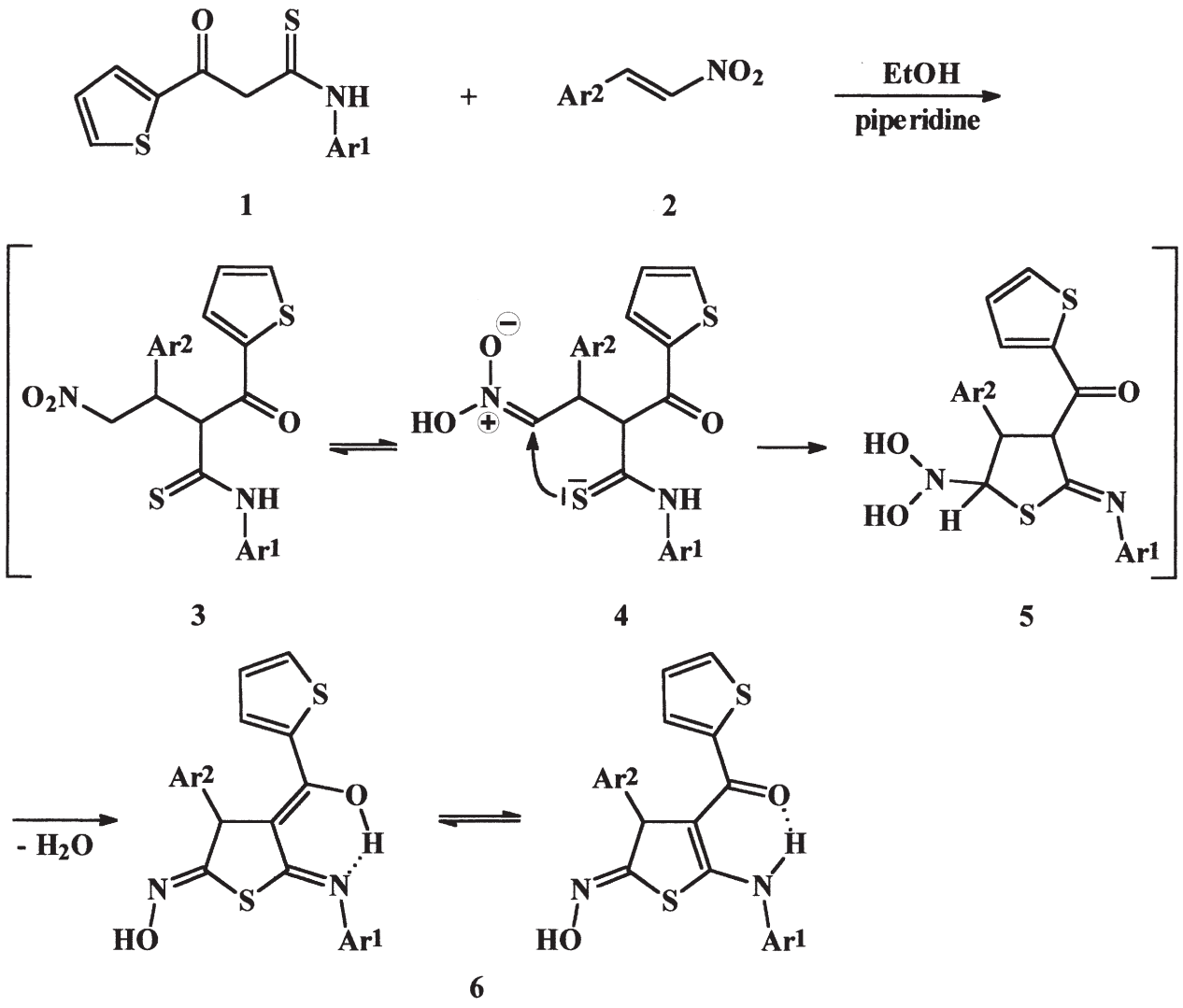


6	Ar¹	Ar²	6	Ar¹	Ar²	6	Ar¹	Ar²
a	C_6H_5	C_6H_5	**g**	*p*-ClC_6H_4	C_6H_5	**m**	*p*-$CH_3C_6H_4$	C_6H_5
b	C_6H_5	*p*-ClC_6H_4	**h**	*p*-ClC_6H_4	*p*-ClC_6H_4	**n**	*p*-$CH_3C_6H_4$	*p*-ClC_6H_4
c	C_6H_5	*p*-$CH_3C_6H_4$	**i**	*p*-ClC_6H_4	*p*-$CH_3C_6H_4$	**o**	*p*-$CH_3C_6H_4$	*p*-$CH_3C_6H_4$
d	C_6H_5	*p*-$CH_3OC_6H_4$	**j**	*p*-ClC_6H_4	*p*-$CH_3OC_6H_4$	**p**	*p*-$CH_3C_6H_4$	*p*-$CH_3OC_6H_4$
e	C_6H_5	*p*-$(CH_3)_2NC_6H_4$	**k**	*p*-ClC_6H_4	*p*-$(CH_3)_2NC_6H_4$	**r**	*p*-$CH_3C_6H_4$	*p*-$(CH_3)_2NC_6H_4$
f	C_6H_5	2-thienyl	**l**	*p*-ClC_6H_4	2-thienyl	**s**	*p*-$CH_3C_6H_4$	2-thienyl

Scheme 1

Techniques used: IR, ^1H and ^{13}C NMR, MS

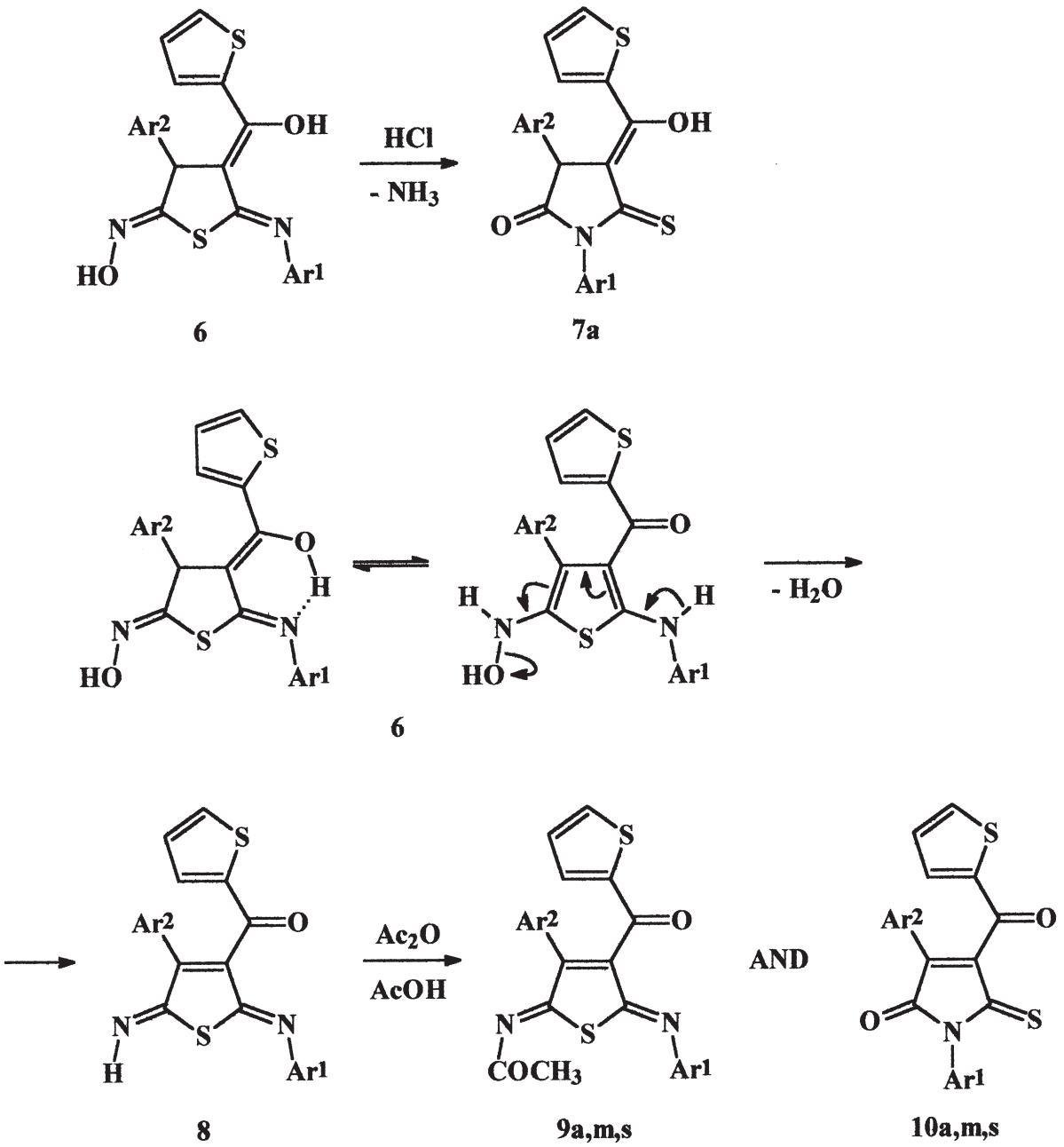
References: 8

Schemes: 2

Tables: 2

Table 1: Physical, analytical and spectroscopic data of compounds **6a-s**

Table 2: Physical, analytical and spectroscopic data of compounds **7a, 9a,m,s,** and **10a,m,s**



7, 9, 10	Ar[1]	Ar[2]
a	C_6H_5	C_6H_5
m	*p*-$CH_3C_6H_4$	C_6H_5
s	C_6H_5	2-thienyl

Scheme 2

Received: 14 April 2002; accepted 11 November 2002.
Paper 02/1328

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