Fries Rearrangement of some 3-Acetoxy- and 3-Propionyloxy-thiophenes

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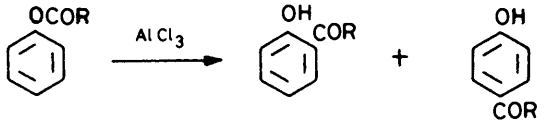
The Fries rearrangement of ten 3-alkanoyloxythiophenes has been studied in dichloromethane using aluminium chloride as catalyst. An intermolecular component of the mechanism has been demonstrated by the observation of all possible mixed products in approximately equal proportions in a crossover experiment. 3-Alkanoyloxythiophenes were prepared from the corresponding 3-hydroxythiophenes and the rearrangement proceeded generally at ambient temperature to give 3-hydroxy-2-alkanoylthiophenes in good yields. This synthetic route provides a useful alternative to the Friedel-Crafts alkanoylation. The structures of both the acyl and 3-thiophenoxy moieties were found to exert an influence on the rearrangement. Acetyl esters rearranged at a faster rate than propionyl esters. An ester or cyano group in the 4-position did not interfere with the rearrangement whereas an acetyl group prevented it; two ester groups in the thiophene ring also prevent rearrangement occurring yielding 3-hydroxythiophenes in almost quantitative yield.

The Fries rearrangement, first studied in 1908,[1] is the rearrangement of a phenolic ester to a hydroxy-ketone, usually in the presence of a Lewis acid such as anhydrous aluminium chloride; choice of reaction conditions (temperature, solvent, and catalyst:ester ratio) influences the composition of the reaction products.



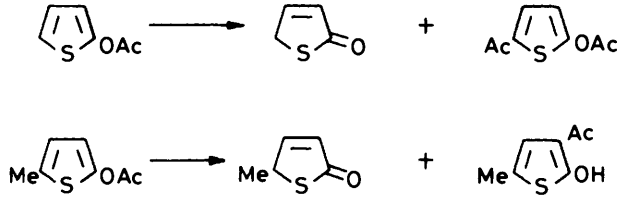
R = alkyl or aryl

The rearrangement is a useful synthetic route to ketones, in spite of the fact that it requires two steps (ester preparation followed by rearrangement), the yield of ketone tending to be better than with the comparable single-step Friedel-Crafts synthesis. This point is illustrated by the Friedel-Crafts acetylation of 3-ethoxycarbonyl-4-hydroxy-2-methylthiophene[2] to yield the 5-acetyl derivative in 43% yield; the acetylation of 4-hydroxy-3-methoxycarbonyl-2-methylthiophene followed by Fries rearrangement gave the 5-acetyl derivative (**14**) in an overall yield of 68%.

The mechanism of the rearrangement is still not completely understood, completely intermolecular,[3–5] completely intramolecular,[6] and partially inter- and intra-molecular mechanisms having been invoked.[7] The results of crossover experiments have been inconclusive, crossover products sometimes being formed,[8] and sometimes not.[6]

The Fries rearranagement of substituted 3-acetoxy- and 3-propionyloxy-thiophenes has received little attention, although rearrangements of heterocyclic compounds such as benzo[*b*]-thiophenes,[9–13] 2-acetoxyfurans, and 2-acetoxythiophenes[14] have been reported. These reports all suggest evidence for an intermolecular mechanism. For example, various groups have observed the rearrangement of 4-acetoxy-,[12] 5-acetoxy-,[13] 6-acetoxy-,[11] and 7-acetoxy-benzo[*b*]thiophenes.[11] Although the possibility of an '*ortho*' product exists in the rearrangement of 4-acetoxybenzo[*b*]thiophene, only the '*para*' product, 7-acetyl-4-hydroxybenzo[*b*]thiophene, is observed in 90% yield.[11] 5-Acetoxybenzo[*b*]thiophene yields the expected '*ortho*' product 4-acetyl-5-hydroxybenzo[*b*]thiophene.[13] In neither case was substitution of the thiophene ring observed. However, 6-acetoxybenzo[*b*]thiophene yields a mixture consisting of 2-acetyl-6-acetoxy- (16%), 3-acetyl-6-acetoxy- (38%), and 6-hydroxy-benzo[*b*]thiophene (39%),[11] which is indicative of an intermolecular mechanism. 7-Acetoxybenzo[*b*]thiophene yielded only the '*para*' product 4-acetyl-7-hydroxybenzo[*b*]-thiophene (10%),[11] together with an intractable tar. When the 3-methyl substituted analogues of 5-acetoxy-[10] and 7-acetoxy-benzo[*b*]thiophene[11] were treated similarly, substitution occurred exclusively at the 2-position of the thiophene ring.

Although 3- and 5-acetyl-2-hydroxythiophene would be the expected reaction products from rearrangement of 2-acetoxythiophene, Kraus and Roth[14] found that with boron trifluoride–diethyl ether as a catalyst, 2-acetoxythiophene yielded a mixture of 5-acetyl-2-acetoxythiophene and dihydrothiophen-2(5*H*)-one.



Rearrangement of 2-acetoxy-5-methylthiophene yielded 3-acetyl-2-hydroxy-5-methylthiophene and 5-methyldihydrothiophene-2(5*H*)-one. Again an intermolecular mechanism is implied. Since 3-acetoxythiophene would be expected to give a single product, 2-acetyl-3-hydroxythiophene, upon rearrangement, and is therefore more easily understood from a mechanistic point of view, we have studied the rearrangement of various 3-acetoxythiophenes.

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Results and Discussion

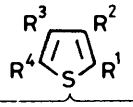
The alkanoylated 3-hydroxythiophenes (**1**)—(**10**) (see Table 1) used in the study were prepared in the main by treatment either of the phenol with acetic anhydride under reflux, or an anhydrous pyridine solution of the phenol with the appropriate alkanoyl chloride (see Table 2). Spectral and analytical data are presented in Table 3.

Although 3-cyano-4-hydroxythiophene could be prepared on a small scale in reasonable yield (52%), a more satisfactory route to 3-acetoxy-4-cyanothiophene (**6**) was developed (see Scheme).

The methyl group of the acetoxy moiety appears as a singlet in the ^{1}H n.m.r. spectrum between δ 2.22 and 2.38 and the carbonyl stretching frequency of the same group is observed between 1 755 and 1 775 cm^{-1}. The rearrangements were carried out in either anhydrous dichloromethane or chloroform using the appropriate number of moles of anhydrous aluminium chloride and in general were found to occur at room temperature. The results are summarized in Table 4 and structural, spectral, and analytical data are presented in Table 5.

The rearrangement was carried out with a mixture of compounds (**7**) and (**10**) in an attempt to find evidence for an intra- or inter-molecular mechanism.

Table 1. Structure of various 2-hydroxythiophenes utilized in the study of the Fries rearrangement

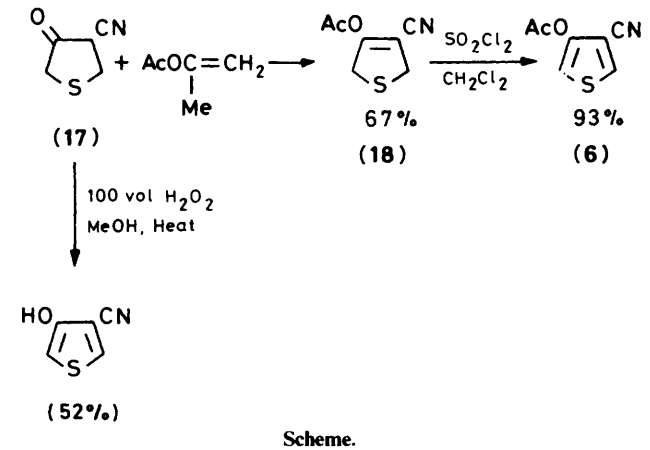


Compd.	R^1	R^2	R^3	R^4
(**1**)	$MeCO_2$	OAc	H	H
(**2**)	$MeCO_2$	OAc	H	$MeCO_2$
(**3**)	H	OAc	H	$MeCO_2$
(**4**)	H	OAc	$MeCO_2$	$MeCO_3$
(**5**)	H	OAc	Ac	H
(**6**)	H	OAc	CN	H
(**7**)	H	OAc	$MeCO_2$	H
(**8**)	H	OAc	$MeCO_2$	Me
(**9**)	H	OCOEt	$MeCO_2$	H
(**10**)	H	OCOEt	$MeCO_2$	Me

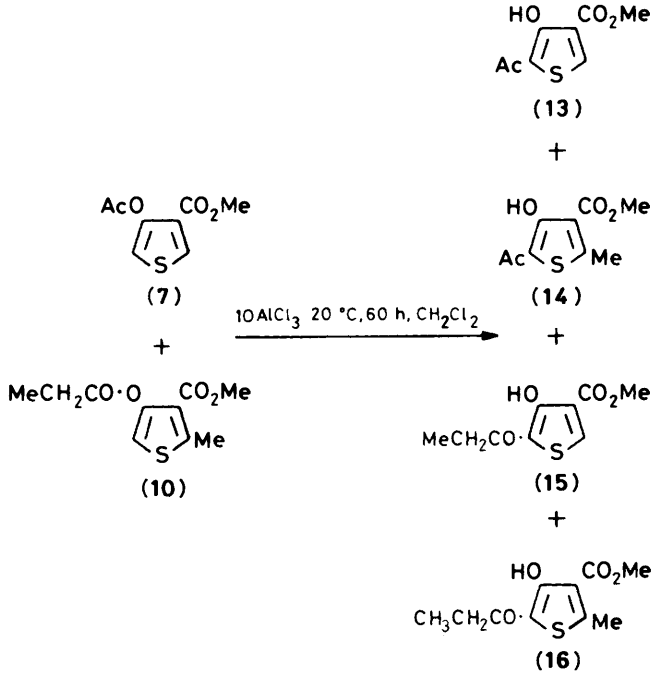
Table 2. Preparative data for 3-acetoxy- and 3-propionyloxy-thiophenes utilized in the study of the Fries rearrangement[a]

Compd.	Phenol (g)	Acetic anhydride (ml)	Pyridine (ml)	Acetyl chloride (ml)	Propionyl chloride (ml)	Reaction time (h)	% Yield (g)
(**1**)	3.0	10				1.5	74 (2.8)
(**2**)	2.0	10				1.0	87 (2.1)
(**3**)	0.7	10				1.0	78 (0.7)
(**4**)	3.0	15				2.0	69 (2.5)
(**5**)	1.6		2	2		0.2	69 (1.4)
(**7**)	2.0		2	2		0.2	71 (1.8)
(**8**)	3.0	10				0.8	86 (3.2)
(**9**)	2.0		5		2	0.3	77 (2.1)
(**10**)	2.0		5		2	0.3	79 (2.1)

[a] For the preparation of compound (**6**), see Experimental section and scheme.



Scheme.



All four possible rearranged products (**13**)—(**16**) were found in the reaction mixture along with a small amount of 4-hydroxy-3-methoxycarbonyl-2-methylthiophene. The rearranged products were found to be in approximately equal proportions (by ^{1}H n.m.r. spectroscopy). The result indicates that there is no intramolecular component in the mechanism (see Experimental section D). The structure of the phenolic portion of ester is the factor of greatest importance in determining whether a Fries rearrangement will take place.[15] If the 3-acetoxythiophene contains a single ester group in the thiophene ring [*e.g.* (**1**), (**3**), and (**7**)], then the position of this substituent has a profound influence on the nature of the product. For example, compound (**1**) yielded only 3-hydroxy-2-methoxycarbonylthiophene whilst (**7**) yielded the rearranged product (**13**) in 79% yield after 24 h at 20 °C. Compound (**3**) at 20 °C gave a mixture of 4-hydroxy-2-methoxycarbonylthiophene and starting material (**3**) under similar conditions, but when heated under reflux in chloroform product (**11**) was formed.

The effect of changing the 4-substituent is of interest, *e.g.* 4-acetyl- (**5**), 4-cyano- (**6**), and 4-methoxycarbonyl-3-acetoxythiophene (**7**). Here compounds (**6**) and (**7**) undergo the rearrangement smoothly to give the rearranged ketone in 56 and 79% yields respectively; but when rearrangement of the

Table 3. Analytical and spectral data of 3-acetoxy- and 3-propionyloxy-thiophenes

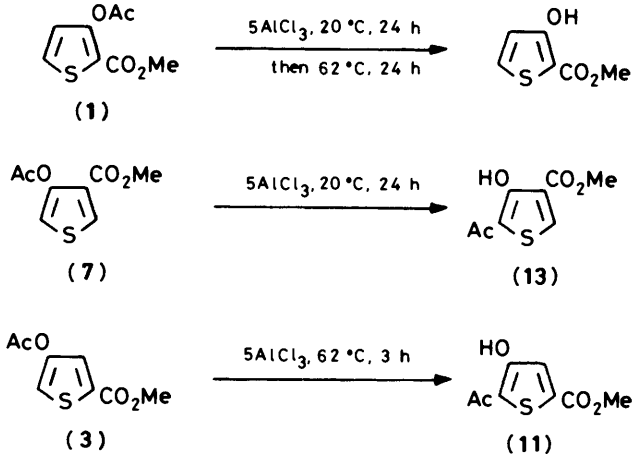
Compd.	M.p. (°C)	B.p. (°C/mmHg)	Molecular formula	Analysis % Found (Calc.) C	H	$\nu_{max.}$(cm^{-1})[d] Ketone C=O	Ester C=O	Misc.	Thiophene proton	^{1}H N.m.r. δ(CDCl$_3$) p.p.m. –OCO*Me*	–COCH$_2$*Me*	–COC*H*$_2$Me	–CO$_2$*Me*	Misc.	Thiophene[e] proton(s)
(1)		85/0.03 86/0.03[a]				1 755	1 711		3 117	2.30			3.0		6.84, 4-H, d, 6 7.44, 5-H, d, 6
(2)	75—76 76[b]					1 760	1 715		3 117	2.38			3.92 3.96		7.76, 4-H, s
(3)		105/0.5	$C_8H_8O_4S$	48.3 (48.0)	4.4 (4.0)	1 765	1 720		3 110	2.22			3.82		7.24, 4-H, d, 2 7.50, 2-H, d, 2
(4)	67—68	138/0.15	$C_{10}H_{10}O_6S$	46.2 (46.5)	3.8 (3.9)	1 769	1 739 1 730		3 111	2.26			3.87 3.91		7.36, 2-H, s
(5)		90/0.1	$C_8H_8O_3S$	51.9 (52.2)	4.4 (4.5)	1 770		1 677 –COMe	3 110	2.27				2.41 –COMe	6.94, 2-H, d, 4 7.95, 5-H, d, 4
(6)		85/0.07	$C_7H_5NO_2S$	unstable		1 770		2 237 –CN	3 118	2.34					7.38, 2-H, d, 3 7.92, 5-H, d, 3
(7)	65—66 67.5[c]	105/0.1				1 760	1 720		3 139 3 100	2.27			3.77		6.98, 2-H, d, 4 8.03, 5-H, d, 4
(8)	74—75	75/0.05	$C_9H_{10}O_4S$	50.6 (50.5)	4.7 (4.7)	1 773	1 712		3 117	2.22			3.74	2.60 2-Me	6.58, 2-H, s
(9)	27—28	108/0.2	$C_9H_{10}O_4S$	50.7 (50.5)	4.7 (4.7)	1 769	1 724		3 119		1.25 t, 6	2.60 q, 6	3.74		6.89, 2-H, d, 4 7.95, 5-H, d, 4
(10)	23—24	122/0.2	$C_{10}H_{12}O_4S$	53.4 (52.6)	5.4 (5.3)	1 766	1 714		3 112		1.22, t, 7	2.55, q, 7	3.74	2.61 2-Me	6.61, 2-H, s

[a] Ref. 24. [b] Ref. 17. [c] Ref. 20. [d] All i.r. were thin film except (7) which was a KBr disc. [e] Thiophene proton column: chemical shift, ring position, splitting pattern, coupling constant (Hz).

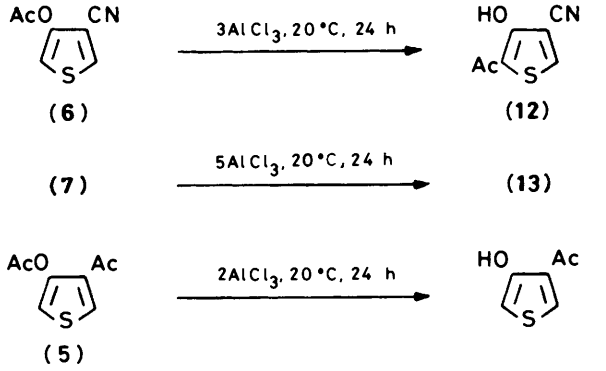
Table 4. Fries rearrangement—experimental details and results carried out on a 1 gram scale

Starting compd.	Product number	Solvent (30 ml)	Equiv. anhyd. $AlCl_3$	Reaction Time (h)	Reaction Temp. (°C)	Yield (%)	Notes
(1)		*a*	5	24	20		Phenol recovered
		b	5	24	62		
(2)		*a*	3	3	20		Phenol recovered
		a	3	8	40		
(3)	11	*a*	5	10	20		Mixture of
		b	5	3	62	30	(11) & phenol
(4)		*a*	5	24	20		Phenol recovered
		a	5	24	40		
(5)		*a*	2	24	20		Phenol recovered
(6)	12	*a*	3	24	20	56	Product is unstable
(7)	13	*a*	5	24	20	79	
(8)	14	*a*	5	24	20	79	
(9)	15	*a*	5	36	20	42	
(10)	16	*a*	5	24	20		Mixture of
		a	5	72	40	50	(16) & phenol

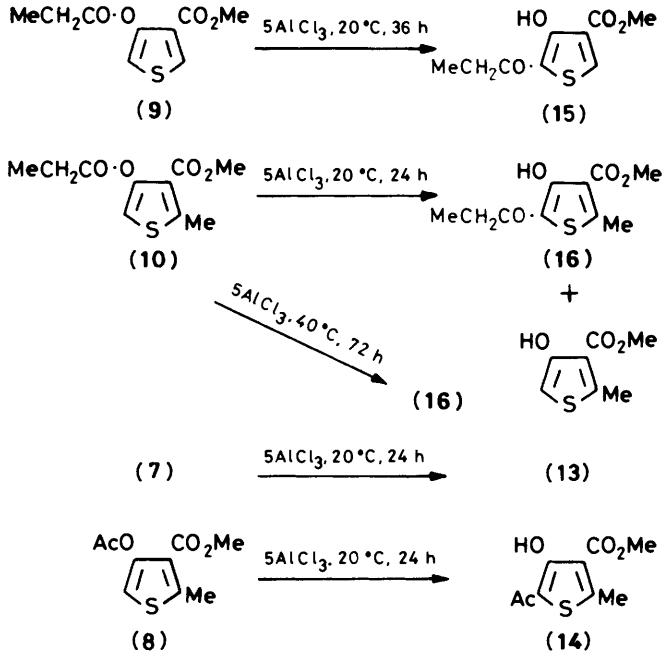
Key: *a* = CH_2Cl_2; *b* = $CHCl_3$.



acetyl compound (**5**) was attempted, only 3-acetyl-4-hydroxythiophene was recovered in good yield.



The rearrangement of propionyl analogues (**9**) and (**10**) was straightforward although they took longer at 20 °C. The apparent sluggishness of the rearrangements of (**9**) and (**10**) seem to be due to the nature of the propionyloxy moiety because when the rearrangements of analogous compounds (**7**) and (**8**) were carried out under the same conditions they were found to be complete after 24 h at 20 °C.



The rearrangement of thiophene derivatives in which two ester groups are present, *e.g.* (**2**) and (**4**), failed, presumably because the ester groups have deactivated the thiophene nucleus to electrophilic attack. In both cases 3-hydroxy-2,5-bismethoxycarbonylthiophene and 4-hydroxy-2,3-bismethoxycarbonylthiophene were recovered in almost quantitative yield. Structures were assigned to the rearranged products on the basis of their ^1H n.m.r. and i.r. spectra. The methyl group of the ketone upon rearrangement underwent a downfield shift of *ca.* 0.2 p.p.m. appearing between δ 2.40 and 2.53 compared with δ 2.22 and 2.45 in the unrearranged products. The position of the thiophene protons in the rearranged compounds is diagnostic. In the main the unrearranged compounds were disubstituted (**1**), (**3**) (**5**), (**6**), (**7**), and (**9**) which led to the protons appearing as doublets with coupling constants between 2 and 6 Hz. Upon rearrangement the compounds became trisubstituted, and the remaining proton appeared as a singlet. In the case of trisubstituted unrearranged compounds (**2**), (**4**), (**8**), and (**10**) the proton appeared as a singlet and if rearrangement took place successfully, it disappeared, *e.g.* (**8**) to (**14**) and (**10**) to (**16**).

The carbonyl stretching frequency of the alkanoyloxy moiety shifts in the rearranged products from around 1 765 cm^{-1} to between 1 645 and 1 610 cm^{-1}, and is accompanied by the appearance of a broad band above 3 100 cm^{-1} due to the hydroxy substituent. Evidence for intramolecular hydrogen bonding between the 3-hydroxy substituent and the 4-ester is seen by the shift of the ester carbonyl stretching frequency in the i.r. spectrum of compounds (**3**) and (**7**)—(**10**). For example, the ester carbonyl is seen between 1 712 and 1 724 cm^{-1} in the alkanoyloxy compounds, but on rearrangement this band is now observed down between 1 675 and 1 685 cm^{-1} (See Tables 3 and 5).

Table 5. Analytical and spectral data of rearranged products (**11**)—(**16**)

Compd.	M.p. (°C)	B.p. (°C/mmHg)	Method of purification[b]	Molecular formula	Analysis Found (Calc.) C	H	$\nu_{max.}$(cm^{-1})[c] Ketone C=O	Ester C=O	Thiophene proton	Misc.	^{1}H N.m.r. δ($CDCl_3$) p.p.m. CO*Me*	$COCH_2$*Me*	$COCH_2CH_2$	CO_2*Me*	Misc.	Thiophene[d] proton
(**11**)	110—111	sublimed 90/0.1	MeOH	$C_8H_8O_4S$	48.3 (48.0)	4.0 (4.0)	1 610	1 710	3 100	3 180 OH	2.44			3.89	11.04 OH	7.24, 4-H
(**12**)	76—80 crude			$C_7H_5NO_2S$	unstable		1 630		3 130	2 235 CN 2 420 OH	2.40					7.84, 5-H
(**13**)	119—120 121[a]		MeOH				1 640	1 685	3 090	3 250 OH	2.53			3.94	10.75 OH	8.23, 5-H
(**14**)	113—114		MeOH	$C_9H_{10}O_4S$	50.8 (50.5)	4.8 (4.7)	1 645	1 679		3 238 OH	2.49			3.94	2.66 5-Me 11.03 OH	
(**15**)	83—84	120/0.5		$C_9H_{10}O_4S$	50.1 (50.5)	4.7 (4.7)	1 645	1 680	3 090	3 190 OH		1.22 t, 7	2.92 q, 7	3.85	10.36 OH	8.24, 5-H
(**16**)	96—97	100/0.1	sublimed 90/0.2	$C_{10}H_{12}O_4S$	52.7 (52.6)	5.4 (5.3)	1 635	1 675		3 180 OH		1.21 t, 7	2.86 q, 7	3.81	2.55 5-Me 10.06 OH	

[a] Reference 20. [b] Method of purification: MeOH—recrystallized from methanol. [c] All i.r. spectra were KBr discs. [d] See Table 3 explanation of 'thiophene proton' column. Signals assigned to OH disappeared upon treatment with D_2O. All the rearranged products gave a deep purple colouration on treatment with ferric chloride solution.

In conclusion, the Fries rearrangement of substituted 3-alkanoyloxythiophene compounds appears to be wholly intermolecular in nature and is sensitive to substitution. The rearrangement occurs readily if there is an ester or cyano group in the 4-position but fails with the corresponding acetyl compound. Rearrangement also fails to occur if an ester group is in the 2-position but proceeds with an ester group in the 5-position.

Experimental

Light petroleum refers to the fraction b.p. 40—60 °C. M.p.s are uncorrected.

A. Preparation of Substituted Hydroxythiophenes.—3-Hydroxy-2-methoxycarbonylthiophene,[16] 3-hydroxy-2,5-bismethoxycarbonylthiophene,[17] 4-hydroxy-2-methoxycarbonylthiophene,[18] 4-hydroxy-2,3-bismethoxycarbonylthiophene,[18] 3-acetyl-4-hydroxythiophene,[19] 3-hydroxy-4-methoxycarbonylthiophene,[18,20] and 4-hydroxy-3-methoxycarbonyl-2-methylthiophene[21] were all obtained by published methods.

3-*Cyano*-4-*hydroxythiophene*. Hydrogen peroxide (100 vol; 3 ml)[22] was added dropwise over 0.1 h to a refluxing solution of 3-cyano-2,3-dihydrothiophen-4(5*H*)-one (**17**)[23] (1 g, 7.87 mmol) in methanol (20 ml). The reaction mixture was heated under reflux for a further 2 h, cooled in ice, and saturated aqueous sodium metabisulphite was then added dropwise, with vigorous stirring, until a negative starch iodide test was obtained. The reaction mixture was evaporated to dryness and the brown tar obtained was extracted with boiling dichloromethane. The combined extracts were dried ($MgSO_4$), treated with charcoal, and evaporated to yield a light brown oil which solidified with time. The product was purified by high vacuum distillation (b.p. 115 °C/0.05 mmHg) to yield a colourless oil (0.51 g, 52%). N.m.r. spectroscopy showed the product to be substantially pure.

B. Preparation of the Acetoxy- and Propionyloxy- Compounds.—The alkanoylations were effected by treatment either of the hydroxythiophene with acetic anhydride under reflux or of an anhydrous pyridine solution of hydroxythiophene with acetyl or propionyl chloride at 0 °C. The following procedures are typical (see Table 2 for preparative data and Table 3 for the appropriate analytical and spectral data).

4-*Acetoxy*-3-*methoxycarbonyl*-2-*methylthiophene* (**8**). 4-Hydroxy-3-methoxycarbonyl-2-methylthiophene (3 g, 17.4 mmol) was heated under reflux in acetic anhydride (10 ml) for 0.75 h. Water (20 ml) was added cautiously to the refluxing solution, which when cool was poured with vigorous stirring into saturated aqueous sodium hydrogen carbonate. The aqueous mixture was extracted with dichloromethane (× 3). The organic extracts were combined, washed with water (× 1), saturated aqueous sodium hydrogen carbonate (× 1), and water (× 1), and then dried ($MgSO_4$) and treated with charcoal; evaporation yielded a tan coloured oil which was purified for analysis by high vacuum distillation (see Table 3 for data) (b.p. 75 °C/0.05 mmHg) to give a colourless oil (3.2 g, 85%). This solidified with time (m.p. 74—75 °C).

3-*Methoxycarbonyl*-4-*propionyloxythiophene* (**9**). To a stirred solution of 3-hydroxy-4-methoxycarbonylthiophene (2 g, 1.26 mmol) in anhydrous pyridine (5 ml; dried over type 4A molecular sieves) at 0 °C propionyl chloride (2 ml) was added dropwise. The dark brown reaction mixture was heated to 50—60 °C for 0.2 h and then poured into water (50 ml). The aqueous mixture was extracted with dichloromethane (× 3) and the organic extracts were combined and washed with 4M-hydrochloric acid (× 2), water (× 1), saturated aqueous sodium hydrogen carbonate (× 1), and water (× 1), and then dried ($MgSO_4$) and treated with charcoal; evaporation yielded a yellow oil. The oil was purified by passage down a short neutral alumina column (dichloromethane as eluant). A sample was distilled for analysis (b.p. 108 °C/ 0.2 mmHg) to yield a white solid (2.1 g, 77%) (m.p. 27—28 °C) (see Table 3 for data).

3-*Acetoxy*-4-*cyano*-2,5-*dihydrothiophene* (**18**). Toluene-*p*-sulphonic acid (0.1 g) was added to a solution of 3-cyano-2,3-dihydrothiophen-4(5*H*)-one (**17**)[23] (2 g, 15.7 mmol) in isopropenyl acetate (20 ml) and the solution was heated under reflux for 8 h. The brown reaction mixture was evaporated under reduced pressure and the resulting oil was distilled under high vacuum to give an unstable colourless oil (1.78 g, 67%), b.p. 78 °C/0.1 mmHg (Found: C, 50.3; H, 4.4; N, 8.2%. $C_7H_7NO_2S$ requires C, 49.7; H, 4.1; N, 8.3%); δ($CDCl_3$) 2.27 (s, –COMe) and 3.91 (m, $-CH_2SCH_2-$); $\nu_{max.}$ (thin film) 2 239m (C≡N), 1 780s (C=O), and 1 660m cm^{-1} (C=C).

3-*Acetoxy*-4-*cyanothiophene* (**6**). To a stirred solution of 3-acetoxy-4-cyano-2,5-dihydrothiophene (**18**) (1 g, 5.91 mmol) in anhydrous dichloromethane (20 ml; dried over type 4A molecular sieves) at −25 °C, sulphuryl chloride (0.90 g, 6.66 mmol)[24] was added dropwise over 0.1 h. The reaction mixture was stirred at −25 °C for 1 h, allowed to come to room temperature, and then left for a further 48 h. The resulting orange solution was poured into water and rapidly stirred for 0.5 h. The aqueous mixture was extracted with dichloromethane (× 3). The organic extracts were combined, washed with water (× 1), saturated aqueous sodium hydrogen carbonate (× 1), and water (× 1), and then dried ($MgSO_4$) and treated with charcoal; evaporation yielded a brown oil which was extracted with hot, light petroleum. The extracts were combined and evaporated to give an oil which was purified by high vacuum distillation to yield an unstable oil (0.9 g, 93%), b.p. 85 °C/0.07 mmHg (see Table 3 for spectral data).

C. Rearrangement.—The conditions employed in individual cases are shown in Table 4 and the following procedure is typical. See Table 5 for appropriate analytical and spectral data.

2-*Acetyl*-3-*hydroxy*-4-*methoxycarbonylthiophene* (**13**). To a stirred solution of 3-acetoxy-4-methoxycarbonylthiophene (**7**) (1 g, 5.00 mmol) in anhydrous dichloromethane (30 ml; dried over type 4A molecular sieves) anhydrous aluminium chloride (3.33 g, 25.0 mmol) was added. The reaction mixture was stirred at 20 °C for 24 h, poured onto crushed ice–2M-hydrochloric acid and stirred for 0.25 h. The aqueous mixture was extracted with dichloromethane (× 3) and the organic extracts were combined and washed once with water, dried ($MgSO_4$), treated with charcoal, and evaporated. The product was recrystallized from methanol to give white needles (0.79 g, 79%), m.p. 119—120 °C (lit.,[20] 120—121 °C) (see Table 5 for data).

D. Crossover Experiment.—To a stirred solution of 3-acetoxy-4-methoxycarbonylthiophene (**7**) (0.15 g, 0.79 mmol) and 3-methoxycarbonyl-2-methyl-4-propionyloxythiophene (**10**) (0.25 g, 0.79 mmol) in anhydrous dichloromethane (30 ml; dried over type 4A molecular sieves) anhydrous aluminium chloride (1.05 g, 7.91 mmol) was added. The reaction mixture was stirred at 20 °C for 60 h and then poured onto crushed ice–2M-hydrochloric acid and stirred for 0.25 h. The aqueous mixture was extracted with dichloromethane (× 3). The organic extracts were combined and washed once with water, dried ($MgSO_4$) and evaporated to yield a brown oil (0.33 g) which was submitted to n.m.r. spectroscopy.

Acknowledgements

The author thanks Professor R. F. Hudson F.R.S. and Dr. P. R. Huddleston for helpful discussions and advice and I.C.I. Pharmaceutical Division for elemental analyses.

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Received 18*th July* 1985; *Paper* 5/1223