A Novel Approach to 1,4-Oxathiocines: The Thermal Rearrangement of Thiophenium Methylides

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2,5-Disubstituted thiophenes react at ambient temperature under rhodium acetate catalysis with various diazoketones to give thiophenium methylides which rearrange thermally to give 1,4-oxathiocines, as confirmed by an *X*-ray crystal structure determination; one of these, 3-ethoxycarbonyl-5,8-dichloro-2-methyl-1,4-oxathiocine, corrects a supposed cyclopropathiophene structure and further rearranges to give ethyl 2,4-dichloro-5-hydroxy-6-methylbenzoate.

Eight-membered 10π annulenes and their hetero-analogues are the subject of constant interest.[1—6] The eight-membered rings in the dianion (**1**),[1] the mono-anions (**2a—c**),[2] and the diheterocines (**2d—f**)[3,4] are all planar, aromatic systems. However, the analogues (**2**) with two oxygen (**2g**),[5] two sulphur (**2h**),[6] or with two nitrogen atoms (**2e**) bearing electron-withdrawing groups (*e.g.* R = tosyl)[3] are non-planar, olefinic systems. The corresponding diheterocines with O,S and N,S hetero-atoms are unknown. Herein we report a novel synthesis of derivatives of the first of these hitherto unknown systems (**3**) and examine their properties.

Thiophenes react with diazomalonates under rhodium acetate catalysis to give thiophenium methylides (**4**).[7,8] With other diazo compounds different types of products are formed, *e.g.* cyclopropathiophenes and 2-substituted thiophenes.[8] We found that 2,5-dichlorothiophenes react with diazoketones to yield related ylides which readily undergo thermal rearrangement to give oxathiocines (**3**). Thus diazodimedone (**5**) appears to react generally with such thiophenes to give the ylides (**7**) at ambient temperature. Upon heating

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(1) (2)

	a	b	c	d	e	f	g	h
X	CH^-	CH^-	CH^-	NH	NR	NH	O	S
Y	NBu^t	NTs	O	NH	NR	O	O	S

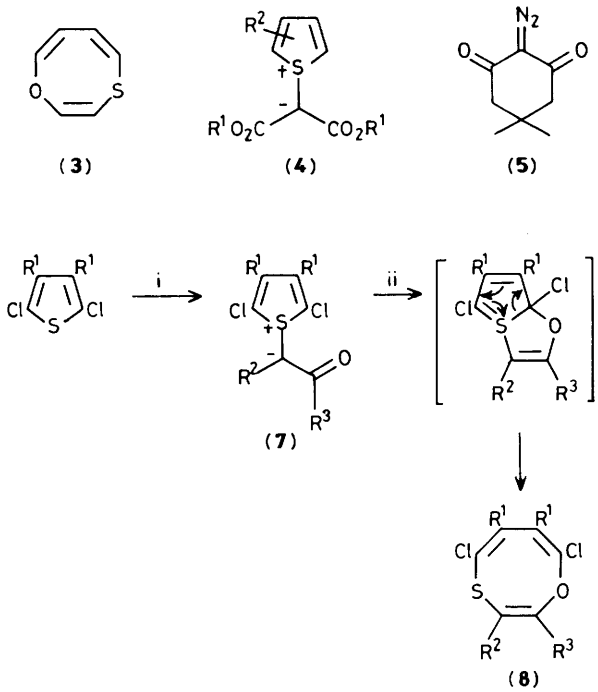
(Ts = tosyl)

(60—100 °C) these ylides (**7**; R^1 = H or Cl) smoothly rearranged to the corresponding oxathiocines [(**8a**) and (**8b**), respectively] (Scheme 1).

With diazoacetoacetates ($MeCOCN_2CO_2R$), the thiophenes gave oxathiocines (**8c—e**) directly, the corresponding ylides rearranging spontaneously. Similar results were observed using tosyldiazoacetone (p-$MeC_6H_4SO_2CN_2COMe$) which yielded the oxathiocine (**8f**).

The structures of the oxathiocines (**8**) were derived from their spectra, in particular their ^{13}C n.m.r. spectra,‡ and from the *X*-ray crystal structure of one of them, (**8b**) (Figure 1).§ This reveals a highly puckered ring system.

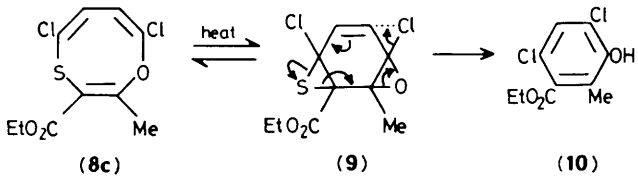
When the oxathiocine (**8c**) was heated more strongly (110 °C) it underwent a further rearrangement to give a benzenoid derivative (**10**) (Scheme 2). The overall reaction of



(3) (4) (5) (7) (8)

	R^1	R^2	R^3
a	H	$COCH_2CMe_2CH_2$	
b	Cl	$COCH_2CMe_2CH_2$	
b	H	CO_2Et	Me
d	Cl	CO_2Et	Me
e	Cl	CO_2Bu^t	Me
f	Cl	Ts	Me

Scheme 1. *Reagents and conditions:* i, $XCOCN_2COY$ (**6**), $Rh_2(OAc)_4$; ii, 60—100 °C.



(8c) (9) (10)

Scheme 2

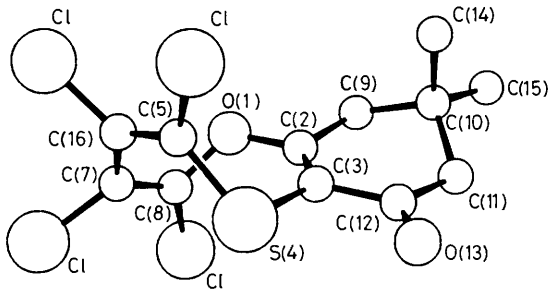


Figure 1. *X*-Ray crystallographic structure of the tetrachloro-oxathiocine (**8b**).

2,5-dichlorothiophene with ethyl diazoacetoacetate to give a product which undergoes a thermal rearrangement to give (**10**) was reported by Porter and co-workers.[9] They identified the intermediate [which corresponded exactly to (**8c**) spectroscopically] as a cyclopropathiophene and remarked on the

‡ *N.m.r. data* for (**8a**): (m.p. 89—90 °C) ^1H n.m.r. ($CDCl_3$, 500 MHz): δ 6.77 (1H, d, *J* 1.5 Hz), 5.99 (1H, d, *J* 1.5 Hz), 2.52 (2H, s), 2.40 (2H, s), 1.08 (6H, s); ^{13}C n.m.r. ($CDCl_3$, 300 MHz): δ 193.29 (CO), 163.87 (C-2), 136.10, 135.59, 125.24, 115.98 (C-5, -6, -7, -8), 112.05 (C-3), 51.39, 45.81 (CH_2 groups), 32.02 (C), 28.16 (Me).

For (**8b**): (m.p. 100 °C) ^1H n.m.r. ($CDCl_3$, 90 MHz): δ 2.58 (2H, s), 2.43 (2H, s), 1.16 (6H, s); ^{13}C n.m.r. ($CDCl_3$, 300 MHz): 193.76 (CO), 165.77 (C-2), 137.36, 135.15, 124.71, 122.71 (C-5, -6, -7, -8), 112.56 (C-3), 50.90, 45.28 (CH_2 groups), 31.68 (C) 29.16, 26.22 (Me groups).

For (**8c**): (oil) ^1H n.m.r. ($CDCl_3$, 90 MHz): δ 6.72 (1H, d, *J* 5 Hz), 5.89 (1H, d, *J* 5 Hz), 4.26 (2H, q, *J* 7 Hz), 2.40 (3H, s), 1.33 (3H, t, *J* 7 Hz); ^{13}C n.m.r. ($CDCl_3$, 300 MHz): δ 164.65 (CO), 159.33 (C-2), 137.23, 136.18, 125.19, 115.07 (C-5, -6, 7, -8), 107.26 (C-3), 61.82 (CH_2), 21.54, 13.90 (Me groups).

For (**8d**): (oil) ^1H n.m.r. ($CDCl_3$, 90 MHz): δ 4.27 (2H, q, *J* 7.5 Hz), 2.42 (3H, s); 1.33 (3H, t, *J* 7.5 Hz); ^{13}C n.m.r. ($CDCl_3$, 300 MHz): δ 164.11 (CO), 160.47 (C-2), 138.44, 135.55, 123.62, 121.87 (C-5, -6, -7, -8), 106.57 (C-3), 62.27 (CH_2), 22.09, 14.02 (Me groups).

For (**8e**): (oil) ^1H n.m.r. ($CDCl_3$, 90 MHz): δ 2.35 (3H, s), 1.48 (9H, s); ^{13}C n.m.r. ($CDCl_3$, 300 MHz): δ 163.19 (CO), 158.78 (C-2), 138.15, 135.76, 123.95, 121.67 (C-5, -6, -7, -8), 107.90 (C-3), 83.58 (C), 27.98, 21.61 (Me groups).

For (**8f**): (m.p. 181—182 °C) ^1H n.m.r. ($CDCl_3$, 90 MHz): δ 7.85 (2H, d, *J* 9.0 Hz), 7.27 (2H, d, *J* 9.0 Hz), 2.51 (3H, s), 2.35 (3H, s); ^{13}C n.m.r. ($CDCl_3$, 300 MHz): δ 161.59 (C-2), 136.27, 135.05, 123.48, 122.12 (C-5, -6, -7, -8), 118.01 (C-3), 145.32, 139.19, 129.77, 128.40 (aromatic C's), 21.70, 21.68 (Me groups).

§ *Crystal data* for (**8b**): $C_{12}H_{10}Cl_{14}O_2S$, monoclinic, space group $P2_1/c$ (No. 14), a = 11.6006(18), b = 11.5154(20), c = 12.1353(20) Å, β = 108.165(15)°, U = 1540.3 Å^3, Z = 4, $F(000)$ = 728, λ = 0.71073 Å, μ(Mo-K_α) = 8.20 mm $^{-1}$. Data were collected on an Enraf-Nonius diffractometer using graphite monochromated Mo radiation. 3691 reflections were measured with $3 \leq \theta \leq 27°$. The structure was solved by direct methods (MULTAN 80) and refined by full-matrix (SHELX 86 programs); anisotropic thermal parameters, hydrogen atoms isotropic. 2109 Reflections with $F_o \geq 2\sigma(F_o)$ were used in the refinement, to give R = 0.050 and R_w = 0.0224. Atomic co-ordinates, bond lengths and angles, and thermal parameters have been deposited at the Cambridge Crystallographic Data Centre. See Notice to Authors, Issue No. 1.

problematic mechanism of the subsequent rearrangement, but confirmed the nature of the thermolysis product (**10**) by *X*-ray crystallography. The first step of this rearrangement to give the intermediate (**9**) is the reverse of the only other approach to the diheterocines (**2**).[1—6] The tendency for sulphur extrusion [to give (**10**)] explains why this method is generally ineffective for the sulphur analogues, as noted earlier.[6]

The unique role of the 2,5-dichloro-substituents is emphasised by the fact that 2,5-dimethylthiophene and 2,5-diiodothiophene react with diazodimedone to give the corresponding 2,5-dimethyl-3-thienyl and 2-iodothien-5-yl dimedone derivatives, respectively.

The last member of the diheterocine family (**2**; X = NR, Y = S) should also be available by this route.

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