Structure and Reactivity of Enamines derived from 5,6-Dihydro-2*H*-thiapyran-3(4*H*)-one 1,1-Dioxide

By **Silvana Fatutta,* Giuliana Pitacco, Claudio Russo,** and **Ennio Valentin,** Istituto di Chimica, Universita, 34127 Trieste, Italy

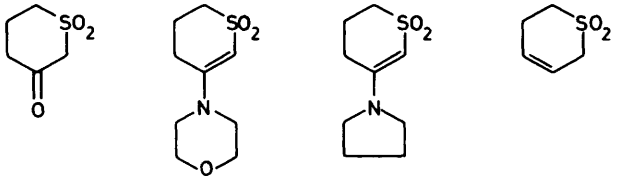
The structures and the reactivities of the title vinylogous sulphonamides are compared with those of the corresponding vinylogous amides derived from cyclohexane-1,3-dione. Their behaviour on alkylation, acylation, and addition-substitution has been studied. Isolation of some of the products can be explained in terms of the existence of a tautomeric equilibrium in the parent systems.

INTEREST in the sulphone group has grown recently as a result both of theoretical studies [1] concerning its structure and of its chemistry.[2] Although comparison of the sulphone group with the carbonyl group should be avoided because of lack of enolization of the former,[3] with caution one structural correlation can be made on the basis of the strong electron-withdrawing properties of the two groups.

In view of these considerations, we have investigated the structure and reactivity of enamines derived from a heterocyclic β-ketosulphone, namely the dihydro-2*H*-thiopyran-3(4*H*)-one 1,1-dioxide (1).[4,5]

RESULTS AND DISCUSSION

It is well known that acyclic and cyclic β-ketosulphones often fail to react with secondary bases to give the corresponding enamines since they undergo ready cleavage.[6] Instead, system (1) furnishes the corresponding enamines (2) and (3), when condensed with morpholine and pyrrolidine respectively, by the method of Stork.[7]



(1) (2) (3) (4)

Both enamines are single isomers, namely Δ^2, as demonstrated by the patterns and areas of their respective vinylic proton signals. The corresponding Δ^3-forms cannot be detected by n.m.r., even under acidic and basic equilibration conditions. Instead, the simple 5,6-dihydro-2*H*-thiapyran 1,1-dioxide (4) is stable only as the Δ^3-isomer.[8] Evidently the electron-donating effect of the base plays an important role in stabilizing the α,β-unsaturated form. It is worthwhile pointing out that this effect is the same in spite of the different basicity of morpholine and pyrrolidine.[9] This is also confirmed by the low value of the double-bond absorption band (1 570 cm^{-1}),[10] found for compounds (2) and (3), when compared with a system possessing no base at the β-position (1 642 cm^{-1}).[11]

On the other hand, a comparison with both simple carbocyclic enamines and carbonyl analogues is also of interest since it provides evidence of the strong influence of the sulphone group both on the structure and on the reactivity of the systems (Table).

Although the bathochromic and ipsochromic shifts of the i.r. and u.v. double-bond absorption bands caused by the sulphone group are remarkable they are, however, less than those due to the carbonyl group. The same trend is observed in the n.m.r. spectra. Evidently the charge density on C-2 is diminished less by the sulphone group than by the carbonyl group.

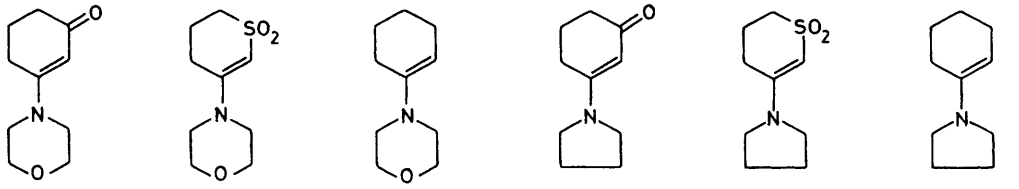
The reactivities of compounds (2) and (3) have been studied under conditions of alkylation, acylation, and addition-substitution. The enamine (2) does not undergo alkylation, whereas (3) reacts with methyl iodide in excess, under reflux, to give compound (5) (Scheme 1). Its structure is demonstrated by the presence of a doublet at δ 1.45 for the methyl group and by the C=$\overset{+}{N}$ stretching band at 1 665 cm^{-1} [also the perchlorate salt of (3) shows the same band at 1 665 cm^{-1}]. Acidic hydrolysis of (5) affords the ketone (6) in quantitative yield. The n.m.r. spectrum of (6) shows a methyl doublet at δ 1.45 and a methine quartet at δ 3.97, thus proving that regiospecific C-2 alkylation has taken place, in spite of steric hindrance from the adjacent sulphone group.

Although the enamine (2) does not undergo acylation either, the reactivity of (3) to acylation depends on the acyl chloride used. With acetyl chloride, at room temperature, acetylation takes place at C-2, to give the β-ketoenaminosulphone (7) (Scheme 2).

The position of the double bond in compound (7) is confirmed by the absence of vinylic proton signals in its n.m.r. spectrum and accounts for the low values of the C=O and C=C stretching bands (1 620 and 1 500 cm^{-1} respectively).[12] When the reaction is carried out in refluxing benzene, a 4 : 1 mixture of compounds (7) and (9) is isolated, from which the other was separated by fractional crystallization. Surprisingly, (9) is a vinylogous sulphonamide and not an enaminone,[12] as clearly indicated by the presence of a vinylic proton signal at δ 5.0 (1 H) and by the position of the C=O and C=C stretching bands at 1 700 and 1 560 cm^{-1} respectively.

It is evident that the electron-withdrawing effect of the sulphone group prevails over that of the carbonyl group in determining the type of isomer produced.

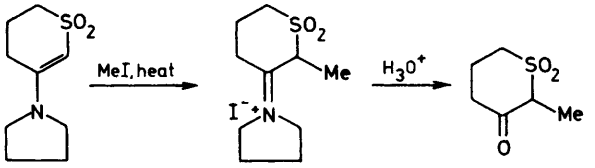
TABLE



		(2)			(3)	
ν(N–C=C)/cm^{-1}	1 560	1 570	1 641 [a]	1 546 [b]	1 570	1 638
δ (C=CH)	5.2 [b]	5.1	4.5 [c]	5.1 [b]	4.7	4.2 [c]
$\lambda_{max.}^{EtOH}$/nm	298	250	222.5 [a]	305	251	233
lg$\epsilon_{max.}$	4.49	4.25	3.90	4.55	4.45	

[a] G. Opitz, H. Hellman, and H. W. Schubert, *Annalen*, 1959, **623**, 112. [b] E. J. Cone, R. H. Garner, and A. W. Hayes, *J. Org. Chem.*, 1972, **37**, 4436. [c] W. D. Gurowitz and M. A. Joseph, *Tetrahedron Lett.*, 1965, 4433.

A remarkable difference has also been found in the β-sulphonyl diketones (8) and (10), derived from hydrolyses of the corresponding enamines (7) and (9). In the former case, the hydrolysis must be performed in



(3) (5) (6)

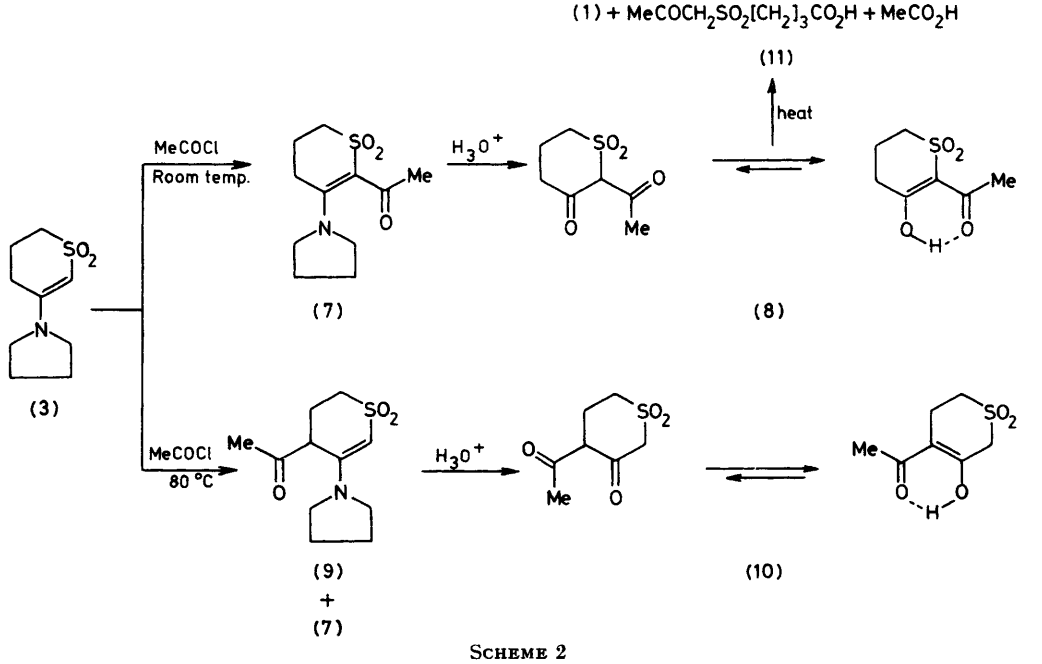
SCHEME 1

aqueous acetonitrile in the presence of a trace of hydrochloric acid at room temperature. Under more acidic conditions, (8) decomposes into the parent ketone (1), acetic acid, and the 7-oxo-5-thiaoctanoic acid 5,5-dioxide (11). It is noteworthy that compound (8) decomposes into compounds (1) and (11) when set aside in the air for two months. Similar behaviour has already been observed for cyclic β-diketones, but only under more forcing conditions (*i.e.* a basic medium with heating).[13] Only in one case does the ring opening occur under acidic conditions.[14] In contrast, the ketone (10), whose enol form prevails in the equilibrium (90%), resists ring fission and conversion into compound (1), both under the same conditions as those described above for compound (8) and with heating.

The reactivity of compound (3) with acetyl chloride proves that an isomerization between the α,β and β,γ-unsaturated forms occurs, at least at 80 °C.

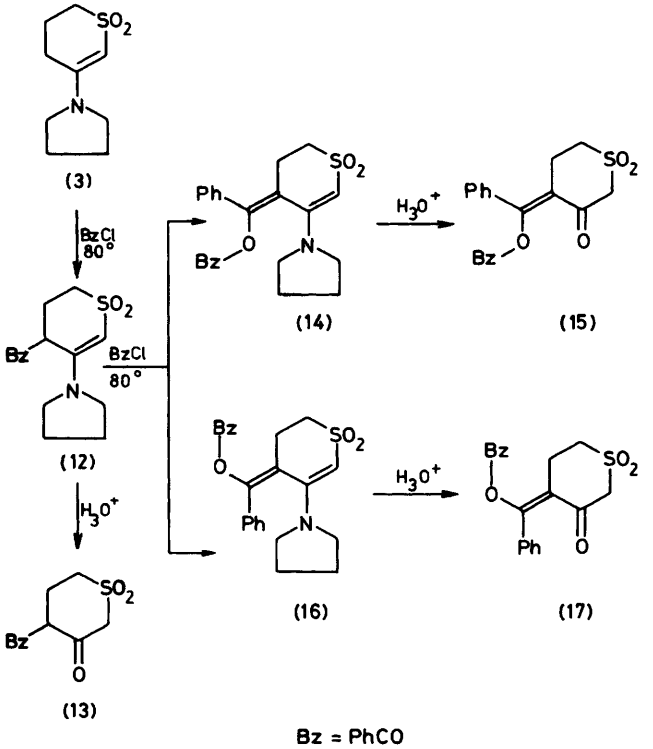
From this point of view, more striking is the reaction of compound (3) with benzoyl chloride in refluxing benzene, which leads to compound (12) as a single product (Scheme 3).

That the compound was a vinylogous sulphonamide with the double bond not in conjugation with the benzoyl



SCHEME 2

group, was indicated by the presence of C=O and C=C absorptions at 1 675 and 1 560 cm^{-1} respectively, and of a vinylic proton singlet at δ 5.05 (1 H). This contrasts with that found for the benzoylated systems derived from cyclohexanone [15] and 5,5-dimethylcyclohexane-1,3-dione,[16] in which the enamine double bond is conjugated



SCHEME 3

with the benzoyl group. On hydrolysis, compound (12) furnishes the corresponding β-diketone (13) which, from its n.m.r. spectrum,[17] gives rise to no enolic form, even after one week in CD_3CN solution. Compound (13) reacts slowly however with ferric chloride to give a characteristic violet colour after few hours.

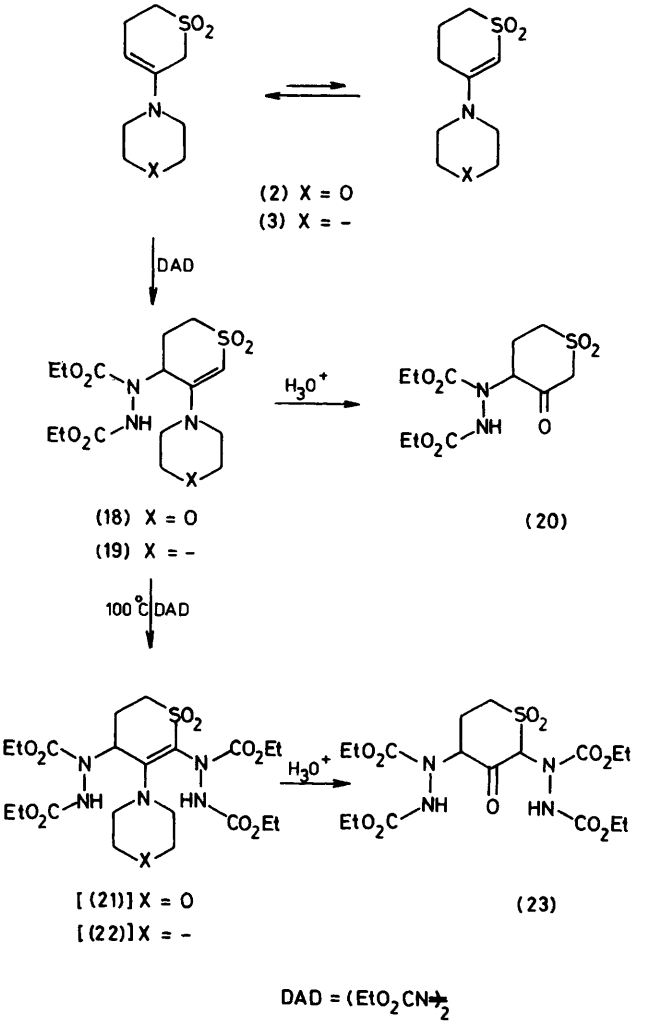
In this reaction the enol esters (14) and (16) are also formed. Only the former could be isolated and identified, while formation of the latter is demonstrated by isolation of the corresponding ketone (17) from the hydrolysis reaction mixture. Structural assignments for compounds (14) and (16) have been made in accordance with the method described by R. Helmers [18] (see Experimental section).

The enamines (2) and (3) react with 1 equiv. of diethyl azodicarboxylate (DAD) to give compounds (18) and (19) respectively (Scheme 4); this is a result of regiospecific attack of the electrophile on C-4 of the tautomeric Δ^3-form.

The adducts (18) and (19) show vinylic proton signals at δ 4.85 and 5.45 respectively and C=C absorption at 1 600 and 1 580 cm^{-1}, thus establishing their identities as enaminosulphones. The latter compounds when hydrolysed gave the same ketone (20) which was identified on the basis of its elemental analyses and spectroscopic results.

When the enamines (18) and (19) are refluxed in toluene for 48 h with a further equivalent of DAD, they partially react to give the corresponding double addition products (21) and (22), which cannot be isolated. Hydrolyses of the crude reaction mixtures, followed by column chromatography separation, afford the ketone (23) as a stable, single isomer.

Conclusions.—The alkylation of the vinylogous sulphonamide (3) is regiospecific in as much as only the C-2 alkylation product is formed. A comparison with the corresponding vinylogous amides, in which the sulphone group is substituted for a carbonyl group, is not possible since, in this case, the *O*-alkylation product is obtained in high yield.[19]



SCHEME 4 Compounds in brackets have not been isolated

At room temperature, acetylation of compound (3) occurs regiospecifically at C-2, while under more forcing conditions, a high degree of regioselectivity is observed, again in favour of C-2 as a site of attack.

In contrast, compound (3) is not benzoylated at room

temperature, whereas at 80 °C it takes place regiospecifically at C-4. The same reaction, performed on the vinylogous amides, always leads to the C-2 acylation products.[19]

Similarly, DAD reacts at C-4 of the vinylogous sulphonamides (2) and (3), whereas it reacts at C-2 of the corresponding vinylogous amides.[20]

The reactivity of compound (3) at the C-2 site is related to the steric properties of the electrophile. In fact, in going from methyl iodide to DAD, a change in regiospecificity is observed. Evidently, the size of the sulphone group, together with its remarkable polarity could account for the preferred attack of bulky and polar systems at C-4. As a consequence, the reactivity at C-4 allows the equilibrium between the Δ^2-and Δ^3-isomers to be demonstrated.

EXPERIMENTAL

^{1}H N.m.r. spectra were recorded with a JNM-60-HL Jeol spectrometer ($SiMe_4$ as internal standard; solutions in $CDCl_3$), i.r. spectra (Nujol mulls) with a Perkin-Elmer 297 spectrophotometer, and u.v. spectra (solutions in EtOH) with a Perkin-Elmer 124 spectrophotometer. For analytical t.l.c., plates were coated with silica gel G (Merck), for chromatographic columns extrapure silica (Merck; 70—230 mesh ASTM) was used as the stationary phase.

Preparation of 3-(*Morpholin*-4-*yl*)-5,6-*dihydro*-4H-*thiapyran* 1,1-*Dioxide* (2).—The enamine (2) was prepared by Stork condensation of ketone (1) [5] and morpholine in benzene. After elimination of the solvent, the crude product (90% yield) was crystallized from benzene–light petroleum, m.p. 195—196 °C (Found: C, 50.0; H, 7.0; N, 6.6. $C_9H_{15}NO_3S$ requires C, 49.8; H, 7.0; N, 6.5%); $\nu_{max.}$ 1 570 (C=C), 1 320 and 1 100 (SO_2), and 1 120 cm^{-1} (CH_2OCH_2); δ 5.10 (1 H, s, vinyl-H), 3.65 (4 H, m, CH_2OCH_2), 3.0 (6 H, m, CH_2NCH_2 and CH_2SO_2), and 2.35 (4 H, m, $CH_2CH_2CH_2SO_2$); $\lambda_{max.}$ 250 nm ($\varepsilon_{max.}$ 17 600).

Preparation of 3-(*Pyrrolidin*-1-*yl*)-5,6-*dihydro*-4H-*thiapyran* 1,1-*Dioxide* (3).—The enamine (3) was prepared by Stork condensation of ketone (1) and pyrrolidine in benzene. After elimination of the solvent, the crude product (90% yield) was crystallized from benzene–light petroleum, m.p. 165—166 °C (Found: C, 53.5; H, 7.7; N, 6.8. $C_9H_{15}NO_2S$ requires C, 53.7; H, 7.5; N, 7.0%); $\nu_{max.}$ 1 570 (C=C) and 1 305 and 1 100 cm^{-1} (SO_2); δ 4.7 (1 H, s, vinyl-H); 3.4—2.8 (6 H, m, CH_2NCH_2 and CH_2SO_2), 2.4 (4 H, m, $CH_2CH_2CH_2SO_2$), and 1.9 (4 H, m, $CH_2CH_2CH_2N$); $\lambda_{max.}$ 251 nm ($\varepsilon_{max.}$ 27 000).

Reaction of 3-(*Pyrrolidin*-1-*yl*)-5,6-*dihydro*-4H-*thiapyran* 1,1-*Dioxide* (3) *with Methyl Iodide*.—The enamine (3) (4.7 g, 23.3 mmol) was refluxed in an excess of methyl iodide for 24 h. On cooling, a white crystalline product (5) separated (7.0 g, 87% yield), m.p. 216—218 °C (Found: C, 35.2; H, 5.1; N, 4.0. $C_{10}H_{18}INSO_2$ requires C, 35.0; H, 5.3; N, 4.1%); $\nu_{max.}$ 1 665 (C=$\overset{+}{N}$) and 1 320 and 1 130 cm^{-1} (SO_2); δ (D_2O) 3.7 (1 H, m, C*H*Me), 3.3 (4 H, m, CH_2NCH_2), 2.8 (2 H, m, CH_2SO_2), 2.5—1.7 (8 H, m, $CH_2CH_2CH_2SO_2$ and $CH_2CH_2CH_2N$), and 1.45 (3 H, d, Me).

The hydrolysis of (5) carried out in water furnished the corresponding ketone (6), identified as 2-*methyl*-5,6-*dihydro*-2H-*thiapyran*-3(4H)-*one* 1,1-*dioxide*,[21] m.p. 80—82 °C Found: C, 44.6; H, 6.0. $C_6H_{10}O_3S$ requires C, 44.4; H, 6.2%); $\nu_{max.}$ 1 725 (CO) and 1 310 and 1 120 cm^{-1} (SO_2); δ 4.95 (1 H, q, *J* 6.75 Hz, C*H*Me), 3.3 (2 H, m, CH_2SO_2), 2.9—1.9 (4 H, m, $CH_2CH_2SO_2$), and 1.5 (3 H, d, *J* 6.75 Hz, Me).

Reaction of 3-(*Pyrrolidin*-1-*yl*)-5,6-*dihydro*-4H-*thiapyran* 1,1-*Dioxide* (3) *with Acetyl Chloride*.—Acetyl chloride (0.39 g, 5 mmol) was added dropwise to a solution of compound (3) (2.01 g, 10 mmol) in dry benzene, in an ice-bath, and the mixture was stirred overnight. The hydrochloride salt was filtered off and the mother liquors concentrated. A solid was isolated and identified as 2-*acetyl*-3-(*pyrrolidin*-1-*yl*)-5,6-*dihydro*-4H-*thiapyran* 1,1-*dioxide* (7) (0.6 g, 43% yield), m.p. 193—194 °C from benzene (Found: C, 54.2; H, 7.0; N, 5.4. $C_{11}H_{17}NO_3S$ requires C, 54.3; H, 7.0; N, 5.8%); $\nu_{max.}$ 1 620 (CO), 1 500 (C=C), and 1 300 and 1 105 cm^{-1} (SO_2); δ 3.5—2.9 (6 H, m, CH_2NCH_2 and CH_2SO_2), 2.5 (3 H, s, Me), and 2.9—1.8 (8 H, m, $CH_2CH_2CH_2SO_2$ and $CH_2CH_2CH_2N$). In another run the reaction was performed in refluxing benzene for 24 h. The hydrochloride salt was filtered off and solvent removed from the filtrate to leave a residue (0.6 g, 52% yield) which contained a 4 : 1 mixture of (7) and (9); this was fractionally crystallized. Compound (9), crystallized from benzene, m.p. 180—181 °C, was identified as 4-*acetyl*-3-(*pyrrolidin*-1-*yl*)-5,6-*dihydro*-4H-*thiapyran* 1,1-*dioxide* (Found: C, 54.1; H, 6.9; N, 5.6. $C_{11}H_{17}NO_3S$ requires C, 54.3; H, 7.0; N, 5.8%); $\nu_{max.}$ 1 700 (CO), 1 560 (C=C), and 1 310, 1 300, and 1 100 cm^{-1} (SO_2); δ 5.0 (1 H, s, vinyl-H), 3.65 (1 H, m, CHCO), 3.4—2.8 (6 H, m, CH_2NCH_2 and CH_2SO_2), 2.6 (2 H, m, CH_2CHCO), 2.3 (3 H, s, Me), and 1.95 (4 H, m, $CH_2CH_2CH_2N$).

Hydrolysis of the Enamine (7).—A solution of the enamine (7) (0.5 g) in acetonitrile (50 ml) was treated with 10% hydrochloric acid (0.75 ml) at room temperature. After 6 h, the solution was concentrated under reduced pressure without heating, and the solid formed was filtered off (0.3 g, 77% yield). The product was crystallized from benzene–light petroleum, m.p. 102—104 °C, and identified as 2-*acetyl*-5,6-*dihydro*-2,4-*thiapyran*-3(4H)-*one* 1,1-*dioxide* (8) (Found: C, 44.1; H, 5.5. $C_7H_{10}O_4S$ requires C 44.2; H, 5.3%); $\nu_{max.}$ 2 700—2 600 (OH), 1 570 (CO–C=C–OH), and 1 300, 1 280, 1 140, and 1 125 cm^{-1} (SO_2); $\nu_{max.}$ ($CHCl_3$) 3 670 and 3 540 cm^{-1} (OH); δ 15.8 (1 H, bs, OH), 3.3 (2 H, m, CH_2SO_2), 2.9—2.0 (7 H, m + s, CH_2CH_2CO,Me), and 2.6 (s, Me). With neutral ferric chloride (8) gave an immediate red colouration. The mother-liquors contained the ketone (1) in traces.

Hydrolytic Cleavage of Compound (8).—A solution of compound (8) (0.1 g) in a 1 : 1 mixture of acetone and 10% hydrochloric acid (10 ml) was refluxed for 8 h. Removal of acetone and extraction with chloroform gave a solid which was chromatographed on silica (eluant : 30% acetone in benzene). Elution furnished 5,6-*dihydro*-2H-*thiapyran*-3(4H)-*one* 1,1-*dioxide* (1) and 7-*oxo*-5-*thiaoctanoic acid* 5,5-*dioxide* (11), m.p. 65—66 °C (Found: C, 40.2; H, 5.6. $C_7H_{12}O_2S$ requires C, 40.4; H, 5.8%); $\nu_{max.}$ *ca.* 3 000 (OH), 1 720 (CO), and 1 310 and 1 130 cm^{-1} (SO_2); δ 10 (1 H, bs, OH), 4.0 (2 H, s, $COCH_2SO_2$), 3.1 (2 H, m, CH_2SO_2), 2.35 (s, Me), and 2.7—1.7 (7 H, m + s, CH_2CH_2 and Me).

Hydrolysis of the Enamine (9).—The enamine (9) (0.2 g) in ethanol or acetonitrile was treated with 10% hydrochloric acid (2 ml), with stirring, at room temperature, for 24 h. Removal of the solvent and extraction with chloroform furnished 4-*acetyl*-5,6-*dihydro*-2H-*thiapyran*-3(4H)-*one* 1,1-*dioxide*, (10), m.p. 116—117 °C, from ethanol (Found: C, 43.9; H, 5.4. $C_7H_{10}O_4S$ requires C, 44.2; H, 5.3%); $\nu_{max.}$

2 600 (OH), 1 630 (CO), 1 580 (COCH=C–OH), and 1 320 and 1 120 cm^{-1} (SO_2); δ 15.8 (0.9 H, s, OH), 4.0 (0.1 H, m, COCHCO), 3.85 (2 H, bs, $COCH_2SO_2$), 3.2 (2 H, m, CH_2SO_2), 2.9 (2 H, m, $CH_2CH_2SO_2$), and 2.2 (3 H, s, Me).

Reaction of 3-(*Pyrrolidin*-1-*yl*)-5,6-*dihydro*-4H-*thiapyran* 1,1-*Dioxide* (3) *with Benzoyl Chloride*.—Benzoyl chloride (0.83 g, 5.5 mmol) was added to a solution of the enamine (3) (2.4 g, 11 mmol) in dry benzene and the mixture was refluxed for 24 h. The hydrochloride salt was filtered off and the mother-liquors were concentrated. A solid formed which was separated and identified as 4-*benzoyl*-3-(*pyrrolidin*-1-*yl*)-5,6-*dihydrothiapyran* 1,1-*dioxide* (12) (0.75 g, 37% yield), m.p. 220—221 °C, from ethanol (Found: C, 63.2; H, 6.1; N, 4.3. $C_{16}H_{19}NO_3S$ requires C, 62.9; H, 6.3; N, 4.6%); $\nu_{max.}$ 1 675 (CO), 1 560 (C=C), and 1 305, 1 105, and 1 095 cm^{-1} (SO_2); δ 8.0 (2 H, m, *o*-ArH), 7.5 (3 H, m, *m*- and *p*-ArH), 5.05 (1 H, s, vinyl-H), 4.55 (1 H, m, CHCO), 3.5—2.2 (8 H, m, CH_2NCH_2 and $CH_2CH_2SO_2$), and 1.8 (4 H, m, $CH_2CH_2CH_2N$). Subsequently, from the benzene mother-liquors a mixture of compounds (12) and (14) was precipitated (0.2 g) from which the latter was isolated by column chromatography (eluant: acetone–benzene, 1 : 3), m.p. 208—209 °C, from ethanol (Found: C, 67.2; H, 5.7; N, 3.5. $C_{21}H_{33}NO_4S$ requires C, 67.5; H, 5.7; N, 3.4%); $\nu_{max.}$ 1 730 (CO), 1 635 (C=C), 1 530 (N–C=C), 1 595, 1 575, 770, and 710 (Ph), 1 300 and 1 100 (SO_2), and 1 260 cm^{-1} (C–O); δ 8.2 (2 H, m, *o*-ArH), 7.45 (8 H, m, *m*- and *p*-ArH), 5.1 (1 H, s, vinyl-H), 3.6—2.4 (8 H, m, $CH_2CH_2SO_2$ and CH_2NCH_2), and 1.6 (4 H, m, $CH_2CH_2CH_2N$).

Finally, the solvent was removed from the mother-liquors, and the residue hydrolysed and extracted with chloroform to furnish a mixture of compounds (13), (15), and (17). The last two were isolated from (13) by column chromatography (eluant: acetone–benzene, 1 : 3). Subsequently they were separated by fractional crystallization from ethanol. Compound (15) had m.p. 187—188 °C (Found: C, 64.2; H, 4.3. $C_{19}H_{16}O_5S$ requires C, 64.0; H, 4.5%); $\nu_{max.}$ 1 730, 1 670 (CO), 1 590, 1 580, 710, 685 (Ph), 1 320, 1 105 (SO_2), and 1 260, 1 240 cm^{-1} (C–O); δ 7.65 (2 H, m, *o*-ArH), 7.25 (8 H, m, *m*- and *p*-ArH), 4.05 (2 H, m, CH_2SO_2), and 3.1 (4 H, m, $CH_2CH_2SO_2$). With neutral ferric chloride compound (15) gave a red colouration within 4—5 h. Compound (17) had m.p. 175—176 °C (Found: C, 63.8; H, 4.5. $C_{19}H_{16}O_5S$ requires C, 64.0; H, 4.5); $\nu_{max.}$ 1 730, 1 695 (CO), 1 635 (C=C), 1 600, 1 585, 1 575, 770, 710 (Ph), 1 340, 1 330, 1 160 (SO_2), and 1 260 and 1 250 cm^{-1} (C–O); δ 7.9 (2 H, m, *o*-ArH), 7.3 (8 H, m, *m*- and *p*-ArH), 4.05 (2 H, bs, $COCH_2SO_2$), 3.3 (2 H, m, CH_2SO_2), and 2.95 (2 H, m, $CH_2CH_2SO_2$). With ferric chloride (16) gave a red colouration within 20 min.

Hydrolysis of Compound (12).—A solution of the enamine (12) (0.2 g) in acetonitrile was treated with 10% hydrochloric acid (2 ml), at room temperature for 24 h. After concentration, a solid was filtered off (0.16 g) which was identified as 4-*benzoyl*-5,6-*dihydro*-2H-*thiapyran*-3(4H)-*one* 1,1-*dioxide* (13), m.p. 193—194 °C from ethanol (Found: C, 57.4; H, 4.9. $C_{12}H_{12}O_4S$ requires C, 57.1; H, 4.8%), $\nu_{max.}$ 1 710, 1 675 (CO), 1 590, 1 580, 750, 680 (Ph), and 1 310—1 280 and 1 130 cm^{-1} (SO_2); δ (CD_3CN) 8.0 (2 H, m, *o*-ArH), 7.65 (3 H, m, *m*- and *p*-ArH), 4.9 (1 H, dd, J_1 7.5 Hz, J_2 8.3 Hz, CHCO), 4.3 (2 H, ABq, $COCH_2SO_2$), and 3.55 (2 H, m, CH_2SO_2). With ferric chloride a violet colour appeared within few hours.

Hydrolysis of Compound (14).—Hydrolysis of the enamine (14), carried out in acetonitrile with 10% hydrochloric acid, at room temperature for 24 h, afforded the ketone (15).

Reaction of 3-(*Morpholin*-4-*yl*)-5,6-*dihydro*-4H-*dihydro*-4H-*thiapyran* 1,1-*Dioxide* (2) *with Diethyl Azodicarboxylate*.—Diethyl azodicarboxylate (0.35 g, 2 mmol) was added to a solution of enamine (2) (0.43 g, 2 mmol) in dry benzene and the mixture set aside for 72 h at room temperature. The white crystalline product was then filtered off (0.73 g, 94% yield) and crystallized from ethanol. It was identified as 3-(*morpholin*-4-*yl*)-4-(N,N′-*diethoxycarbonylhydrazino*)-5,6-*dihydro*-4H-*thiapyran* 1,1-*dioxide* (18), m.p. 170—171 °C (Found: C, 46.3; H, 6.6; N, 10.4. $C_{15}H_{25}N_3O_7S$ requires C, 46.0; H, 6.4; N, 10.7%); $\nu_{max.}$ 3 290 (NH), 1 745, 1 675 (CO), 1 590 (C=C), 1 510 (NH), 1 300—1 280 (SO_2), and 1 125—1 110 cm^{-1} (SO_2 and C–O–C); δ 6.65 (1 H, bs, NH), 5.45 (1 H, s, vinyl-H), 5.1 (1 H, bm, CH–N), 4.2 (4 H, bq, 2 CH_2Me), 3.7 (4 H, m, CH_2OCH_2), 3.5—2.8 (6 H, m, CH_2-NCH_2 and CH_2SO_2), 2.8—2.2 (2 H, m, $CH_2CH_2SO_2$), and 1.3 (6 H, t, 2 Me).

Reaction of 3-(*Pyrrolidin*-1-*yl*)-5,6-*dihydro*-4H-*thiapyran* 1,1-*Dioxide* (3) *with Diethyl Azodicarboxylate*.—Diethyl azodicarboxylate (0.35 g, 2 mmol) was added to a solution of compound (3) (0.4 g, 2 mmol) in dry benzene and the mixture was set aside at room temperature for 72 h. The precipitate was then filtered off (0.7 g, 93% yield), crystallized from ethanol, and identified as 3-(*pyrrolidin*-1-*yl*)-4-(N,N′-*diethoxycarbonylhydrazino*)-5,6-*dihydro*-4H-*thiapyran* 1,1-*dioxide* (19), m.p. 170—171 °C (Found: C, 48.3; H, 6.7; N, 10.9. $C_{15}H_{25}N_3O_6S$ requires C, 48.0; H, 6.7; N, 11.2%), $\nu_{max.}$ 3 240 (NH), 3 050 (=C–H), 1 750, 1 760 (CO), 1 580 (C=C), 1 530 (NH), and 1 330, 1 300, and 1 110 cm^{-1} (SO_2); δ 6.9 (1 H, bs, NH), 5.1—4.6 (2 H, bm + s, CHN and vinyl-H), 4.85 (s, vinyl-H), 4.1 (4 H, m, 2 CH_2Me), 3.1 (6 H, bm, CH_2NCH_2 and CH_2SO_2), 2.6 (2 H, m, $CH_2CH_2SO_2$), 1.9 (4 H, m, $CH_2CH_2CH_2N$), and 1.25 (6 H, t, 2 Me).

Hydrolyses of Compounds (18) *and* (19).—Enamines (18) and (19) (0.2 g) were separately dissolved in ethanol or acetonitrile and 10% hydrochloric acid was added. After 24 h at room temperature a solid formed (0.15 g) and was identified as 4-(N,N′-*diethoxycarbonylhydrazino*)-5,6-*dihydro*-2H-*thiapyran*-3(4H)-*one* 1,1-*dioxide* (20), m.p. 155—156 °C, from ethanol (Found: C, 41.0; H, 5.6; N, 8.5. $C_{11}H_{18}N_2O_7S$ requires C, 41.0; H, 5.6; N, 8.7%); $\nu_{max.}$ 3 340 (NH), 1 730, 1 690 (CO), 1 500 (NH), and 1 320 and 1 140 cm^{-1} (SO_2); δ 6.6 (1 H, bs, NH), 5.0 (1 H, m, CHN), 4.4—3.7 (6 H, m, 2 CH_2Me and $COCH_2SO_2$), 3.35 (2 H, m, CH_2SO_2), 2.4 (2 H, m, $CH_2CH_2SO_2$), and 1.25 (6 H, t, 2 Me).

Reaction of 3-(*Morpholin*-4-*yl*)-4-(N,N′-*diethoxycarbonylhydrazino*(-5,6-*dihydro*-4H-*thiapyran* 1,1-*Dioxide* (18) *and* 3-(*Pyrrolidin*-1-*yl*)-4-(N,N′-*diethoxycarbonylhydrazino*)-5,6-*dihydro*-4H-*thiapyran* 1,1-*Dioxide* (19) *with Diethyl Azodicarboxylate*.—Diethyl azodicarboxylate (0.1 g, 0.5 mmol) was added to a solution of compound (18) (0.25 g, 0.6 mmol) [or (19) (0.2 g, 0.6 mmol)] in dry toluene. The mixture was refluxed for 48 h. After elimination of the solvent, the residues were hydrolysed in ethanol with 10% hydrochloric acid, for 24 h, and the mixture extracted with chloroform. The double-addition product (23) was isolated from compound (20), derived from the unchanged (18) [or (19)], by column chromatography (eluant: acetone–benzene, 1 : 3). It was identified as 2,4-*bis*(N,N′-*diethoxycarbonylhydrazino*)-5,6-*dihydro*-2H-*thiapyran*-3(4H)-*one* 1,1-*dioxide*, m.p. 178—180 °C (Found: C, 41.5; H, 5.9; N, 10.9. $C_{17}H_{28}N_4O_{11}S$ requires C, 41.1; H, 5.7; N, 11.3%); $\nu_{max.}$ 3 300 (NH), 1 770—1 690 (CO_2Et,CO), 1 380, 1 140, 1 125 (SO_2); δ 7.4—

6.5 (3 H, 3bs, 2NH + $NCHSO_2$), 5.8—5.0 (1 H, vbs, CHN), 4.3 (8 H, bq, 4 CH_2Me_3), and 2.3 (12 H, bt, 4 Me).

This work was supported by C.N.R. (Rome).

[2/158 *Received*, 26*th January*, 1982]

REFERENCES

[1] I. Hargittai, ' Sulfone Molecular Structures,' ed. Springer-Verlag, Berlin, 1978.
[2] P. D. Magnus, *Tetrahedron*, 1977, **33**, 2019.
[3] J. Strating, ' Organic Sulfur Compounds,' ed. N. Kharasch, Pergamon Press, Oxford, 1961, vol. 1, p. 146.
[4] E. A. Fehnel, *J. Am. Chem. Soc.*, 1952, **74**, 1569.
[5] K. Sato, S. Inoue, and K. Kondo, *J. Org. Chem.*, 1971, **36**, 2077.
[6] J. J. Looker, *J. Org. Chem.*, 1966, **31**, 2714.
[7] A. G. Cook, ' Enamines: Synthesis, Structure, and Reactions,' ed. Marcel Dekker, New York, 1969, pp. 55, 313.
[8] M. Muzika, M. Procházka, and M. Paleček, *Collect. Czech. Chem. Commun.*, 1969, **34**, 635.
[9] G. Stork, A. Brizzolara, H. Landesman, J. Szmuszkovicz, and R. Terrell, *J. Am. Chem. Soc.*, 1963, **85**, 207.
[10] F. Benedetti, G. Pitacco, and E. Valentin, *Tetrahedron*, 1979, **35**, 2293.
[11] W. Truce and J. R. Norell, *J. Am. Chem. Soc.*, 1963, **85**, 3231.
[12] G. Opitz and E. Tempel, *Annalen*, 1966, **699**, 74.
[13] S. Hünig and W. Lendle, *Chem. Ber.*, 1960, **93**, 909.
[14] S. Hünig and M. Salzwedel, *Chem. Ber.*, 1966, **99**, 823.
[15] F. P. Colonna, G. Pitacco, and E. Valentin, *Tetrahedron*, 1971, **27**, 5481.
[16] G. H. Alt and A. J. Speziale, *J. Org. Chem.*, 1964, **29**, 798.
[17] S. Forsén and M. Nilsson, ' The Chemistry of Functional Groups. The Chemistry of the Carbonyl Group,' vol. 2, ed. S. Patai, J. Wiley and Sons, 1970.
[18] R. Helmers, *Acta Chem. Scand.*, 1965, **19**, 2139.
[19] J. V. Greenhill, *Chem. Rev.*, 1977, **6**, 277.
[20] F. P. Colonna, G. Pitacco, and E. Valentin, *J. Chem. Soc., Chem. Commun.*, 1975, 71.
[21] B. Eistert and M. Regitz, *Chem. Ber.*, 1963, **96**, 2260.