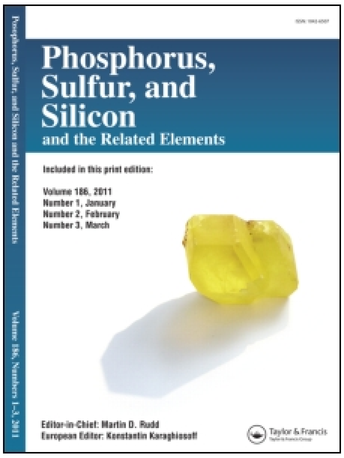

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THE EFFECTS OF RING MODIFICATION ON THE MASS SPECTROMETRIC FRAGMENTATION OF SOME 2, 3-DIARYL-1, 3-THIAZOLIDIN-4-ONES UNDER ELECTRON IMPACT

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THE EFFECTS OF RING MODIFICATION ON THE MASS SPECTROMETRIC FRAGMENTATION OF SOME 2,3-DIARYL-1,3-THIAZOLIDIN-4-ONES UNDER ELECTRON IMPACT

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The effects of ring modification on the mass spectral fragmentations of 2,3-diaryl-1,3-thiazolidin-4-ones were established by comparing their spectra with those of their S-oxides and with compounds in which the aromatic groups at C(2) or N(3) had been replaced by non-aromatic substituents. 3-Benzyl-2-phenyl-1,3-thiazolidin-4-one and 3-butyl-2-phenyl-1,3-thiazolidin-4-one gave mass spectra which differed from those of the diaryl compounds in ways which could largely be accounted for by the absence of N-aryl p-π overlap and by the stability of the benzyl ion formed from the former compound. 3-Phenyl-2-thioxo-1,3-thiazolidin-4-one was found to break down to give ions analogous to those formed in the spectra of the diaryl compounds and by loss of ketene or of a hydrogen atom from the molecular ion. Generally, the loss of oxygen from the molecular ions of the sulphoxides was not important in their mass spectra. Instead, their fragmentation was found to occur mainly by formation of the protonated form of the Schiff base and by cleavage of the N-aryl bond to give an aryl ion. The sulphone 2-(3′-bromophenyl)-3-phenyl-1,3-thiazolidin-4-one-1,1-dioxide appeared to be less stable than the corresponding sulphoxide and was found to lose sulphur dioxide from its molecular ion.

Key words: 1,3-Thiazolidin-4-ones, ring modifications, S-oxides, mass spectrometry, fragmentation.

INTRODUCTION

As part of our continuing study of the mass spectrometric properties of thiazolidinones, we have investigated the effects of ring modification on the fragmentation of the 2,3-diaryl-1,3-thiazolidin-4-ones (**1**) as discussed in our earlier paper.[1] The spectra of these compounds were compared with those of their sulphoxides (**2**) and, in one case, with its sulphone (**3**), and with those of 3-benzyl-2-phenyl-1,3-thiazolidin-4-one (**4a**), 3-butyl-2-phenyl-1,3-thiazolidin-4-one (**4b**) and 3-phenyl-2-thioxo-1,3-thiazolidin-4-one (**5**).

The elemental compositions of the principal fragmentation products were verified by exact mass measurements.

RESULTS AND DISCUSSION

As demonstrated in our earlier paper,[1] the mass spectral fragmentation of the 2,3-diaryl-1,3-thiazolidin-4-ones (**1**) results in the formation of the ions

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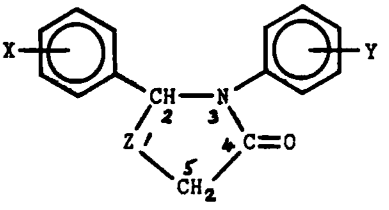
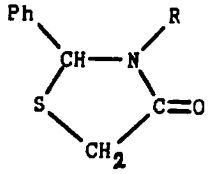


	Z
1	S
2	SO
3	SO_2

In the text, Ar refers to XC_6H_4 and Ar' to YC_6H_4.

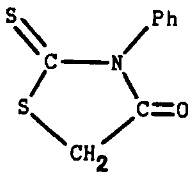
Sulphoxides (2) and sulphones (3):

	X	Y		X	Y
2a	H	H	2e	4-Cl	H
2b	4-OMe	H	2f	3-Br	H
2c	4-Me	H	2g	H	4-OMe
2d	3-OMe	H	2h	H	3-Br
			3	3-Br	H



4a R = Bz

4b R = Bu



5

$[ArCH{=}NAr']^{+\cdot}$ (a), $[ArC{\equiv}NAr']^+$ (b), $[ArCHNHAr']^+$ (c), $[CH{=}NAr']^+$ (d), $[ArH]^{+\cdot}$ (e), $[Ar]^+$ (f), $[NAr']^{+\cdot}$ (g), $[ArCH_2]^+$ (h), $[M - Ar]^+$ (i), $[ArC_2H_3S]^{+\cdot}$ (j), $[ArC_2H_2S]^+$ (k), $[C_8H_7S]^+$ (l), $[ArCHNCO]^+$ (m), $[CH_2{=}SAr']^+$ (n), $[ArC{\equiv}S]^+$ (o), and $[Ar']^+$ (p), the abundances of ions m, n and o being related to the electron-donating or -withdrawing properties of the substituents in the aromatic rings. The formation of these sixteen ions was found to be extensively modified by S-oxidation and by the other structural changes described here (see the following and Tables I and II).

TABLE I

70 eV Mass spectra of compounds **2a**–**2h** and **3**: m/z (% relative intensity of base peak)[a]

Ion	**2a**	**2b**	**2c**	**2d**	**2e**	**2f**	**2g**	**2h**	**3**
$\mathrm{M}^{+\cdot}$	271 (32)	301 (36)	285 (28)	301 (24)	305 (18)	349 (7)	301 (28)	349 (11)	365 (0)
$[\mathrm{ArCH{=}NAr'}]^{+\cdot}$ (a)	181 (0)	211 (0)	195 (0)	211 (0)	215 (29)	259 (10)	211 (26)	259 (0)	259 (71)
$[\mathrm{ArC{=}NAr'}]^{+}$ (b)	180 (37)	210 (56)	194 (35)	210 (32)	214 (32)	258 (12)	210 (8)	258 (25)	258 (0)
$[\mathrm{ArCHNHAr'}]^{+}$ (c)	182 (100)	212 (100)	196 (100)	212 (100)	216 (100)	260 (48)	212 (100)	260 (100)	260 (0)
$[\mathrm{CH{=}NAr'}]^{+}$ (d)	104 (20)	104 (14)	104 (15)	104 (29)	104 (20)	104 (22)	134 (7)	182 (8)	104 (28)
$[\mathrm{ArH}]^{+\cdot}$ (e)	78 (6)	108 (2)	92 (2)	108 (3)	112 (3)	156 (1)	78 (1)	78 (13)	156 (1)
$[\mathrm{Ar}]^{+}$ (f)	77 (70)[b]	107 (0)	91 (14)[b]	107 (1)	111 (3)	155 (1)	77 (12)	77 (20)	155 (0)
$[\mathrm{NAr'}]^{+\cdot}$ (g)	91 (2)[b]	91 (3)	91 (14)[b]	91 (3)	91 (2)	91 (2)	121 (6)[b]	169 (0)	91 (1)
$[\mathrm{ArCH_2}]^{+}$ (h)	91 (2)[b]	121 (2)	105 (2)	121 (2)	125 (7)	169 (0)	91 (2)	91 (8)	169 (0)
$[\mathrm{ArC_2H_2S}]^{+}$ (k)	135 (2)	165 (40)	149 (1)	165 (2)	169 (2)	213 (0)	135 (7)	135 (5)	213 (0)
$[\mathrm{C_8H_7S}]^{+}$ (l)		135 (4)	135 (7)[b]	135 (2)	135 (28)	135 (4)			135 (0)
$[\mathrm{ArCHNCO}]^{+}$ (m)	132 (0)	162 (6)	146 (3)	162 (1)	166 (1)	210 (0)	132 (0)	132 (3)	210 (0)
$[\mathrm{CH_2{=}SAr'}]^{+}$ (n)	123 (4)	123 (0)	123 (2)	123 (2)	123 (39)	123 (6)	153 (9)	201 (2)	123 (0)
$[\mathrm{ArC{=}S}]^{+}$ (o)	121 (4)	151 (8)	135 (7)[b]	151 (7)	155 (4)	199 (1)	121 (6)[b]	121 (26)	199 (0)
$[\mathrm{Ar'}]^{+}$ (p)	77 (70)[b]	77 (62)	77 (57)	77 (73)	77 (90)	77 (100)	107 (3)	155 (25)	77 (100)
$[\mathrm{C_2H_2O_2S}]^{+\cdot}$	90 (6)	90 (4)	90 (4)	90 (4)	90 (8)	90 (9)	90 (2)	90 (14)	90 (12)
$[\mathrm{M}^{+\cdot} - \mathrm{O}]$			269 (3)		289 (16)		285 (5)		
$[\mathrm{PhCH{=}NC_6H_4O}]^{+}$							196 (31)		
$[\mathrm{MeOC_6H_4C{=}SO}]^{+}$		167 (8)		167 (9)					
$[\mathrm{M}^{+\cdot} - \mathrm{SO_2}]$									301 (21)
$[\mathrm{M}^{+\cdot} - \mathrm{SO_2Br}]$									222 (7)

[a] Only ions containing ^{12}C, ^{32}S, ^{35}Cl and ^{79}Br are recorded. All intensities have been corrected for other isotopic contributions.

[b] Mixed peaks.

[c] Identities confirmed by exact mass measurements.

TABLE II

70 eV Mass spectra of compounds **4a**, **4b** and **5**: m/z (% relative intensity of base peak)[a]

4a		**4b**		**5**	
M$^{+\cdot}$	269 (4)[c]	M$^{+\cdot}$	235 (100)	M$^{+\cdot}$	209 (100)[c]
[PhCH=NBz]$^{+\cdot}$	195 (2)	[PhCH=NBu]$^{+\cdot}$	161 (4)	[SC=NPh]$^{+\cdot}$	135 (89)[c]
[PhC=NBz]$^{+}$	194 (29)[c]	[PhC=NBu]$^{+}$	160 (62)		
[PhCHNHBz]$^{+}$	196 (1)	[PhCHNHBu]$^{+}$	162 (15)	[SCNHPh]$^{+}$	136 (32)
[CH=NBz]$^{+}$	118 (4)	[CH=NBu]$^{+}$	84 (6)	[CH=NPh]$^{+}$ (d)	104 (16)[c]
[PhH]$^{+\cdot}$ (e)	78 (1)	[PhH]$^{+\cdot}$ (e)	78 (4)		
[Ph]$^{+}$ (f)	77 (9)	[Ph]$^{+}$ (f)	77 (17)		
[NBz]$^{+\cdot}$	105 (1)	[NBu]$^{+\cdot}$	71 (0)	[NPh]$^{+\cdot}$ (g)	91 (19)
[PhCH$_2$]$^{+}$ (h)	91 (100)[b]	[PhCH$_2$]$^{+}$ (h)	91 (72)	[SCH]$^{+}$	45 (8)
[M$^{+\cdot}$ − Ph] (i)	192 (2)	[M$^{+\cdot}$ − Ph] (i)	158 (41)	[M$^{+\cdot}$ − S]	177 (0)
[PhC$_2$H$_3$S]$^{+\cdot}$ (j)	136 (1)	[PhC$_2$H$_3$S]$^{+\cdot}$ (j)	136 (12)	[C$_2$H$_2$S$_2$]$^{+\cdot}$	90 (2)
[PhC$_2$H$_2$S]$^{+}$ (k)	135 (8)	[PhC$_2$H$_2$S]$^{+}$ (k)	135 (46)	[C$_2$HS$_2$]$^{+}$	89 (0)
[PhCHNCO]$^{+}$ (m)	132 (6)	[PhCHNCO]$^{+}$ (m)	132 (78)	[SCNCO]$^{+}$	86 (0)
[CH$_2$=SBz]$^{+}$	137 (6)	[CH$_2$=SBu]$^{+}$	103 (3)	[CH$_2$=SPh]$^{+}$ (n)	123 (5)
[PhC=S]$^{+}$ (o)	121 (2)	[PhC=S]$^{+}$ (o)	121 (12)	[S=C=S]$^{+}$	76 (13)
[Bz]$^{+}$	91 (100)[b]	[Bu]$^{+}$	57 (12)	[Ph]$^{+}$ (p)	77 (66)[c]
[PhCH=N]$^{+}$	104 (21)	[PhCH=N]$^{+}$	104 (35)		
[M$^{+\cdot}$ − Bz]	178 (44)[c]	[M$^{+\cdot}$ − Bu]	178 (8)		
		[M$^{+\cdot}$ − Pr]	192 (30)		
		[M$^{+\cdot}$ − CH$_2$CO]	193 (10)	[M$^{+\cdot}$ − CH$_2$CO]	167 (19)[c]
		[PhCHNHCH$_2$]$^{+\cdot}$	119 (5)	[M$^{+\cdot}$ − H]	208 (38)
		[PhCH=NCH$_2$]$^{+}$	118 (39)	[CNPh]$^{+\cdot}$	103 (19)[c]
		[PhC=NCH$_2$]$^{+\cdot}$	117 (6)	[C$_6$H$_4$]$^{+\cdot}$	76 (13)
		[CHNCH$_2$]$^{+\cdot}$	41 (15)		

[a] Only ions containing ^{12}C, ^{32}S, ^{35}Cl and ^{79}Br are recorded. All intensities have been corrected for other isotopic contributions.

[b] Mixed peaks.

[c] Identities confirmed by exact mass measurements.

Replacement of the N-Aryl Group by a Butyl or Benzyl Group

The effects of these replacements appeared to be largely accounted for by the absence of N—Ar′ p-π overlap in **4a** and **4b** and by the formation of a stable $[C_7H_7]^+$ ion from **4a**.

Whereas loss of the *N*-substituent as an uncharged species was not observed in the spectra of the diaryl compounds (**1**), due, no doubt, to the strengthening effect of p-π overlap in the N—Ar′ bond, it was found in the spectra of **4a** and **4b** in which p-π overlap was absent. The abundance of the $[M^{+\cdot} - Bz]$ ion at m/z 178 in the spectrum of **4a** was high (100% at 20 eV and 44% at 70 eV) and a similar ion, $[M^{+\cdot} - Bu]$ at m/z 178, was observed in the spectrum of **4b** although the $[M^{+\cdot} - Pr]$ ion at m/z 192 was more abundant.

The molecular ion from **4b** formed the base peak at both 20 and 70 eV. Possibly this was a result of the inhibition of the formation of the ion $[CH_2{=}SBu]^+$, analogous to ion n which often gave rise to the base peak in the spectra of the diaryl compounds (**1**). In contrast, the abundances of the molecular ion from **4a** were low (10% at 20 eV and 4% at 70 eV) and this could have been a result of its extensive breakdown both by loss of an uncharged benzyl group, as mentioned previously, and by the formation of $[Bz]^+$.

The formation of the ions i and o and of the ions $[PhCH{=}NBz]^{+\cdot}$ and $[PhCHNHBz]^+$, analogous to ions a and c, was found to be inhibited in the mass spectrum of **4a**. However, the ion $[PhC{=}NBz]^+$ (29%) was observed with abundance comparable with that of ion b in the spectra of the diaryl compounds (**1**).

Some further breakdown of the Schiff base and its derivatives seemed to occur by loss of $Bz^{\cdot}$ for **4a** and usually by the loss of $Pr^{\cdot}$ rather than $Bu^{\cdot}$ for **4b**.

Loss of ketene was observed from the **4b** molecular ion and resulted in the ion at m/z 193. In contrast, analogous ions in the spectra of the diaryl compounds (**1**) were either absent or occurred with very low abundances.

Replacement of the C-Aryl Group by a Thioxo Group

Important ions in the spectrum of **5** included $M^{+\cdot}$, d, g, n and p; ions analogous to a, c and h with S replacing a Ph group and an H atom, or to o with S replacing just a Ph group; and those commented on later.

Loss of a hydrogen atom from the molecular ion from **5** was found to occur at both 20 and 70 eV, giving rise to ions of abundances 25% and 38%, respectively.

Loss of ketene from the molecular ion was also observed, the composition of the resulting ion at m/z 167 being confirmed by exact mass measurement.

The ion at m/z 103, with abundances 9% (20 eV) and 19% (70 eV), was shown by exact mass measurement to correspond to $[CNPh]^{+\cdot}$. It seems likely that this ion was formed by the loss of an S atom from the $[SC{=}NPh]^{+\cdot}$ ion at m/z 135, the composition of which was also confirmed by exact mass measurement.

Oxidation to the Sulphoxide

Loss of the oxygen atom from the molecular ion was not observed in the spectra of **2a**, **2b**, **2d**, **2f** and **2h** and resulted in low intensity $[M^{+\cdot} - O]$ ions for **2c** and

2g (3% and 5%, respectively). However, in the spectrum of compound **2e**, the $[M^{+} - O]$ ion at m/z 289 was observed with abundances of 14% (20 eV) and 16% (70 eV). The explanation for the exceptional behaviour of this compound was not readily apparent.

The most important breakdown products in the spectra of the majority of the sulphoxides examined were found to be the ions $[ArCHNHAr']^+$ (c) and $[Ar']^+$ (p) with the former ion usually resulting in the base peak. The Schiff base ion (a) was not observed in the spectra of **2a**–**2d** and **2h** although the deprotonated Schiff base ion (b) was observed in the spectra of all the sulphoxides.

The ion $[CH{=}NAr']^+$ (d) was found to be present in the spectra of the sulphoxides at moderate abundances similar to those observed in the spectra of the non-oxidised compounds (**1**). The ions $[Ar]^+$ (f) were only observed at significant abundances in the spectra of **2g** and **2h**. (The peaks at m/z 77 and 91 in the spectra of **2a** and **2c**, respectively, were both mixed.) The ions $[ArH]^{+}$ (e), $[NAr']^{+}$ (g) and $[ArCH_2]^+$ (h) appeared generally to be of little importance in the mass spectra of the sulphoxides.

Loss of the Me group from the Schiff base ion was observed in the spectrum of **2g** (as well as from 3-(4'-methoxyphenyl)-2-phenyl-1,3-thiazolidin-4-one as mentioned in our earlier paper[1]). The resulting ion $[PhCH{=}NC_6H_4O]^+$ at m/z 196 was observed with abundances of 9% (20 eV) and 31% (70 eV).

Loss of the *C*-aryl group was found to be totally inhibited in the mass spectra of the sulphoxides, possibly because the resulting ion (i) with a positive charge at C(2) would have been destabilised by the presence of the adjacent electronegative sulphoxide group.

The ion $[ArCHNCO]^+$ (m) was only observed in the mass spectra of compounds **2b**, **2c** and **2h** (these being the sulphoxides of the diaryl compounds which had themselves produced ions m of greatest abundance) and in these cases the ions produced were of low abundance. It therefore appears that similar electronic factors influence the abundance of this ion for the sulphoxides as for the nonoxidised compounds.

The ion $[CH_2{=}SAr']^+$ (n)[1] was only observed at significant abundance in the spectra of **2a**, **2e**, **2f** and **2g**. Since the formation of this ion involves the loss of oxygen, the readiness with which this takes place from the SO group is probably important in determining the ionic abundance. This agrees with the fact that for these four compounds ion n was only observed at high abundance (39%) in the spectrum of **2e**, this being the only sulphoxide which, as mentioned previously, readily loses oxygen from the molecular ion.

The ion $[ArC_2H_2S]^+$ (k) was only found to be of importance in the spectra of **2b**, **2g** and **2h**. For **2e**, however, the ion $[C_8H_7S]^+$ (l) was observed in place of the expected ion indicating that the Cl atom had been eliminated in place of an H atom.

The ion $[ArC{=}S]^+$ (o) was generally observed at low abundance, the notable exception being in the spectrum of **2h** in which the $[PhC{=}S]^+$ ion was observed at 26% abundance. In the spectra of **2b** and **2d**, a similar ion was also observed without loss of oxygen, giving $[MeOC_6H_4C{=}SO]^+$ ions of abundances 8% and 9%, respectively.

Oxidation to the Sulphone

The spectra of the sulphone (**3**) did not show a molecular ion when electron ionisation was used although an $[M + 1]^+$ ion was seen using chemical ionisation. Hence, it appears that, under electron impact, **3** is less stable than the corresponding sulphoxide (**2f**) and the thiazolidinone (**1**, X = 3-Br, Y = H) from which it was prepared.

The electron ionisation spectrum showed an $[M^{+\cdot} - 64]$ ion as the peak of highest mass indicating loss of SO_2. Further breakdown took place by the loss of ketene to yield the Schiff base ion (a). Other ions of importance in the mass spectrum of **3** were $[CH{=}NPh]^+$ (d), and $[Ph]^+$ (p).

EXPERIMENTAL

The compounds were prepared as described in some of our earlier papers,[1–4] using modifications of well-established methods.[5–8]

Mass spectra were obtained under the same conditions as stated in our previous paper on mass spectrometry.[1] Chemical ionisation was carried out using 2-methylpropane as reactant gas with a beam energy of *ca.* 100 eV.

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