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THE MASS SPECTROMETRIC BEHAVIOUR OF ISOMERIC 1,3-BENZOXATHIOLE AND 1,4-BENZOXATHIANE DERIVATIVES

Maria Teresa Cocco, Antonio Maccioni, and Gianni Podda*
Istituto di Chimica Farmaceutica, Tossicologica ed Applicata,
University of Cagliari, Via Ospedale 72, 09100 Cagliari, Italy

Giampietro Frison and Pietro Traldi*
Area di Ricerca del CNR Padova
Corso Stati Uniti 4, 35100 Padova, Italy

Abstract - The mass spectrometric behaviour of isomeric 1,3-benzoxathiole and 1,4-benzoxathiane derivatives has been studied in detail with the aid of accurate mass measurements, B/E and B^2/E linked scans and Mass Analyzed Ion Kinetic Energy Spectra. While the molecular ions maintain the original structures, some fragment ions isomerize to a common structure(s). The related electron impact induced decomposition mechanisms are discussed in detail.

Ring enlargement and ring contraction reactions represent well described processes either in condensed phase or in gas phase chemistry. Particularly, in mass spectrometric conditions (i.e. in the chemistry of gaseous ions) these reactions have been widely described and their driving force is mostly due to thermodynamic factors, such as the higher stability of the product ions.

Thus, for example, 2,3-dihydrobenzoxepine loses a methyl group leading to chromenyl cation[1], 3-hydroxy-2,3,4,5-tetrahydro-1-benzoxepine shows a partial isomerization to the corresponding 2-hydroxymethylchromane isomers[2], 4 and 5-methylbenzimidazoles isomerize to a 1,3-diazaazulene[3].

In particular in the mass spectrometry of 1,4-benzoxathianes an isomerization to the corresponding 1,3-benzoxathioles has been proposed by Caputo and Martin[4], in order to explain the observed primary loss of $CH_2COOC_2H_5^{\cdot}$ from the 2-carboethoxy-1,4-benzoxathiane molecular ion.

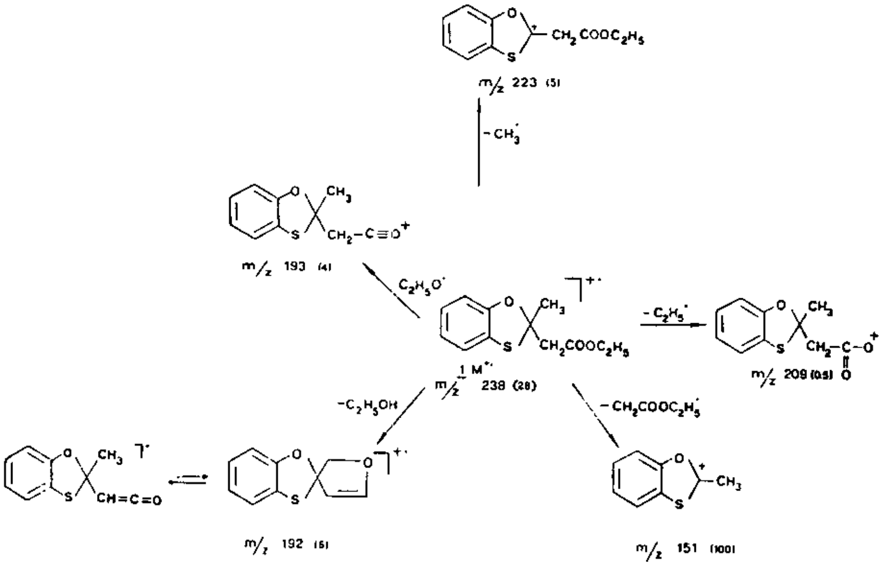
Pursuing our interest in both sulfur containing compounds[5] and benzodioxole-benzoxathiole derivatives[6], we undertook the present investigation on 1,3-benzoxathiole-2-acetic acid, 2-methyl-ethyl ester 1, 2-methyl-3-carbethoxy-1,4-benzoxathiane 2 and 2,2-dimethyl-3-carbomethoxy-1,4-benzoxathiane 3 with the aid of studying possible Electron Impact (EI) induced isomerization processes either of molecular ions or of common fragmentation products.

Results and discussion

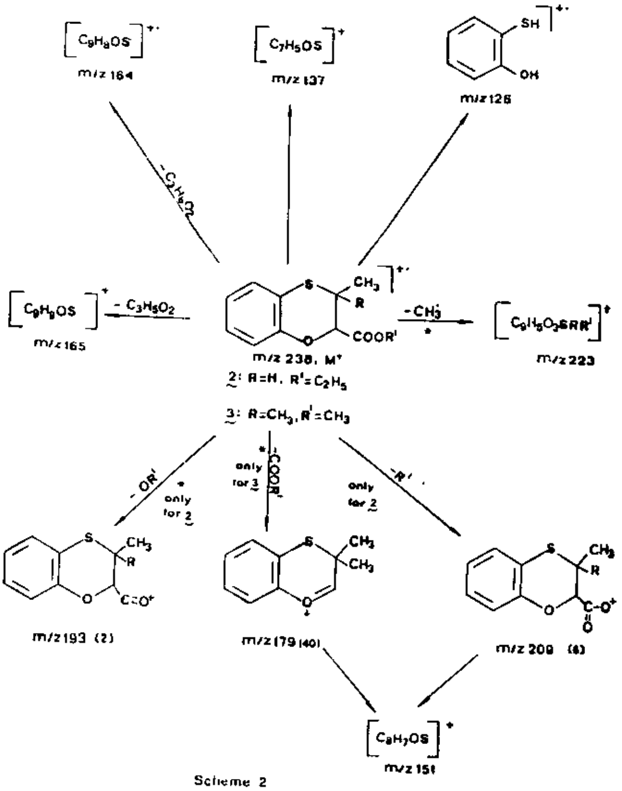
The 70 eV EI mass spectra of compounds 1-3 are reported in Table 1. Compound 1 shows a behaviour strictly related to what has already been described for other 1,3-benzoxathiole derivatives[6]. In fact, by means of linked scans and accurate mass measurements, the fragmentation pattern reported in scheme 1 was obtained. The loss of methyl or $CH_2COOC_2H_5$ radicals lead to the resonance-stabilized cations at m/z 223 and m/z 151 respectively. The latter decomposition pathway resulted highly favoured, giving rise to the base peak in the mass spectrum. Cleavage of ester bond with and without H rearrangement leads to the ions at m/z 192 and m/z 193, while the primary $C_2H_5^{\bullet}$ loss gives rise to the ionic species at m/z 209. The already described[6] primary formation of 2-hydroxythiophenol is also observed.

Table 1 : 70 eV EI mass spectra of compounds 1-3

Compounds Ionic species	1	2	3
$M^{+\cdot}$ (m/z 238)	28	25	100
$[M - CH_3]^+$ (m/z 223)	5	1	1
$[M - C_2H_5]^+$ (m/z 209)	0.5	6	-
$[M - CH_3O]^+$ (m/z 207)	-	-	8
$[M - CH_4O]^{+\cdot}$ (m/z 206)	-	-	57
$[M - C_2H_5O]^+$ (m/z 193)	4	2	-
$[M - C_2H_6O]^{+\cdot}$ (m/z 192)	6	7	-
$[M - C_2H_3O_2]^+$ (m/z 179)	-	-	40
$[M - C_3H_5O_2]^{+\cdot}$ (m/z 165)	-	40	10
$[M - C_3H_6O_2]^{+\cdot}$ (m/z 164)	-	23	24
$[C_8H_7OS]^+$ (m/z 151)	100	34	9
$[C_7H_5OS]^+$ (m/z 137)	-	18	34
$[C_6H_6OS]^{+\cdot}$ (m/z 126)	4	28	3
$[C_7H_5S]^+$ (m/z 121)	2	12	19
$[C_6H_9O_2]$ (m/z 113)	-	3	24
$[C_5H_5S]^+$ (m/z 97)	10	42	17
$[C_3H_3]^+$ (m/z 39)	5	100	44



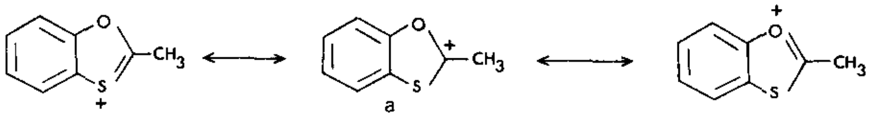
Scheme 1



Scheme 2

Compounds 2 and 3 show a peculiar behaviour easily interpreted in terms of different molecular structures. Their fragmentation pathways are sumarized in Scheme 2. Cleavage of the ester bonds is responsible for most of the fragmentation products, while a retrosynthetic reaction gives rise to the ionic species at m/z *126*. From Table 1 it can be seen that compounds 1-3 give rise to fragmentation ions at the same m/z value.

We considered it of interest to study the structures of these ions by means of MIKE experiments, in order to determine *possible isomerization processes. The ions* at m/z 151, of molecular formula C_8H_7OS, are present for all the compounds. Its high abundance for 1 suggests the structure of the resonance stabilized ions already described for other 1,3-benzoxathiole derivatives, either in solution chemistry or in mass spectrometric *conditions:*



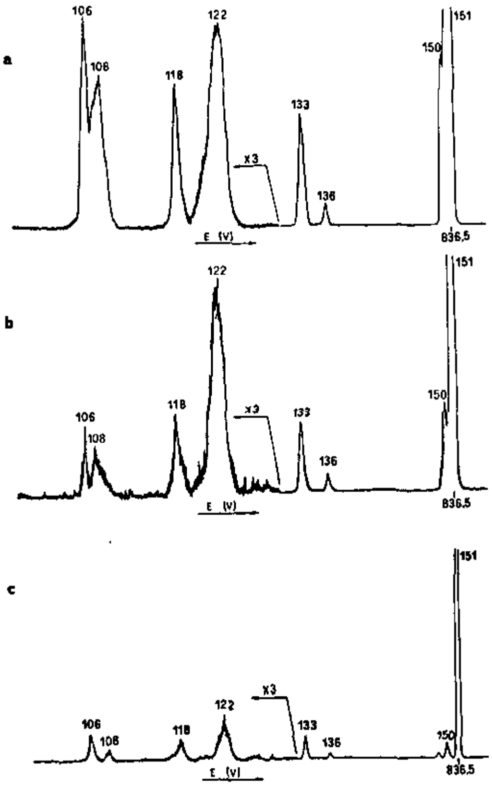


Figure 1 - MIKE spectra of ionic species at m/z 151 originating from EI of :
a) compound 1; b) compound 2; c) compound 3.

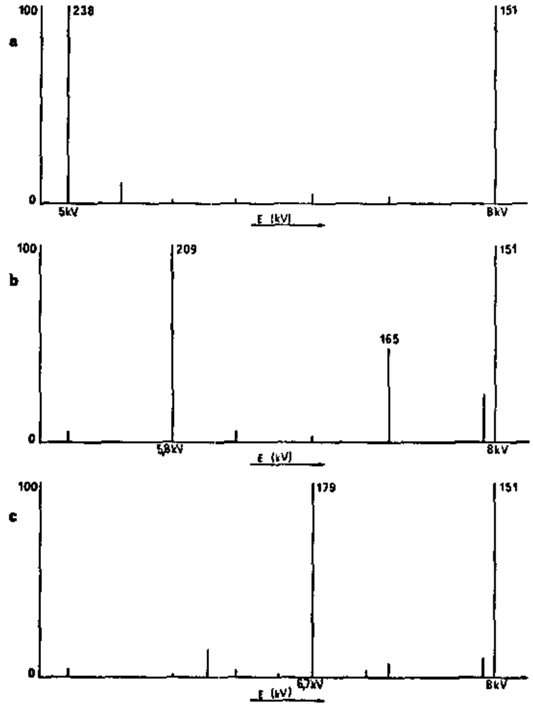
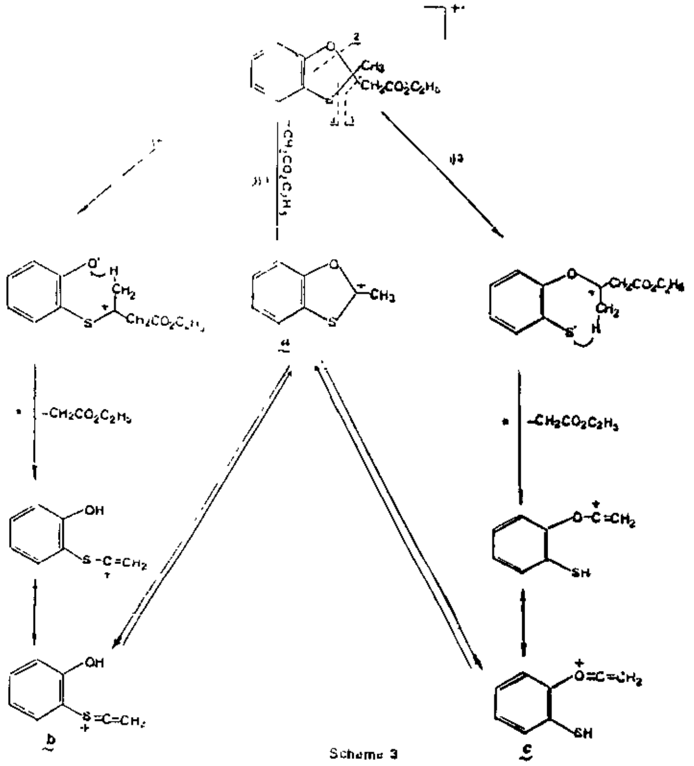


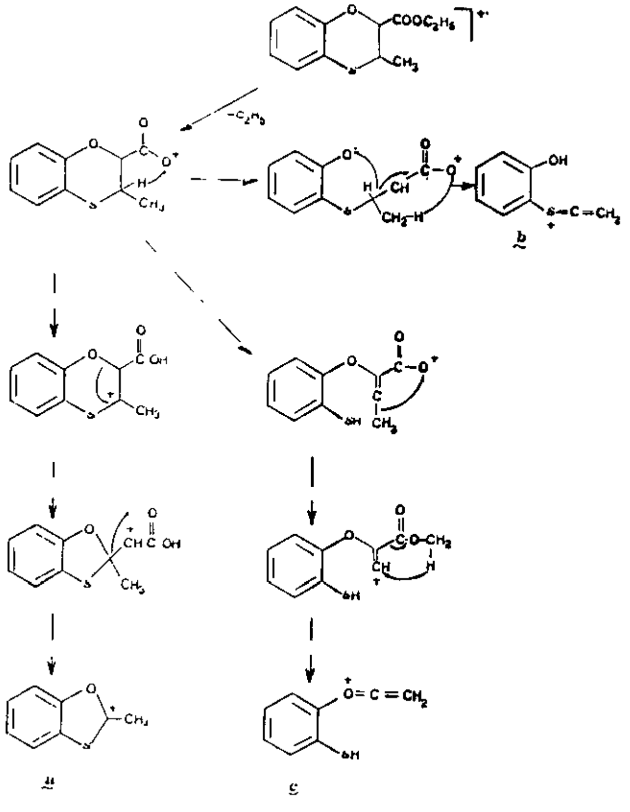
Figure 2 - B^2/E linked scans of ionic species at m/z 151 originating from EI of a) compound 1; b) compound 2; c) compound 3.

The MIKE spectra of ionic species at m/z 151 originating from EI of 1-3 are practically superimposable (see Fig. 1). The naturally occurring decomposition of these ionic species are mainly due to $CH_3^{\cdot}$, H_2O, $CHO^{\cdot}$, $SH^{\cdot}$, $CH_3CO^{\cdot}$ and $CHS^{\cdot}$ losses.

While the losses of $CH_3^{\cdot}$ and $CH_3CO^{\cdot}$ are in agreement with the benzoxathiolic structure (a), the losses of H_2O and $CHO^{\cdot}$ are better related to the presence of substituted phenol. On the contrary the losses of $SH^{\cdot}$ and $CHS^{\cdot}$ are in agreement with a structure of a substituted thiophenol. Hence from the above findings we are forced to propose the presence of differently structured ionic species at m/z 151, i.e. 2-dehydro-2-methyl-1,3-benzoxathiole (a), 2-hydroxyphenyl vinylidene sulfonium (b) and 2-mercaptophenyl vinylidene oxonium (c). B^2/E linked scans show that the ionic species at m/z 151 originate preferentially from $M^{+\cdot}$ for compound 1 and from the ionic species at m/z 209 and m/z 179 for compounds 2 and 3 respectively (see Fig. 2). The mechanism for the formation of $C_8H_7OS^+$ ions for 1 is show in Scheme 3. Ions a originate by simple cleavage of the C(2)-CH_2 bond. The cleavage of O(1)-C(2) bond leads to molecular species in a open structure which, through $^{\cdot}CH_2COOC_2H_5$ loss and H rearrangement, gives rise to ions b.



Scheme 3



Scheme 4

Finally, ions c originate through the analogous mechanism starting from the cleavage of the thioethereal bond.

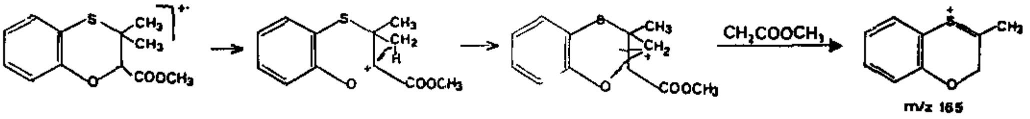
For compound 2 (see scheme 4) the formation of ions a can be explained first by an H rearrangement process followed by ring contraction with further loss $C_2H_2O_2^{\cdot}$. For the formation of ions b and c the cleavage of ethereal and thioethereal bonds respectively must be invoked also in this case.

For compound 3 a more exstensive rearrangement may be required to give ions a, b and c. which must necessarily pass through the rearrangement of the dimethyl geminal moiety. On the contrary, either the molecular ions or the $[M-CH_3]^+$ ionic species of compounds 1-3 give rise to clearly different MIKE spectra, proving that in these ions the original structures are maintained.

For compounds 2 and 3 abundant ionic species at m/z 164 and m/z 165 are present. Accurate mass measurements and linked scans demonstrate that they originate from primary losses of $C_3H_6O_2^{\cdot}$ and $C_3H_5O_2^{\cdot}$ respectively. While for compound 2 these fragmentation processes can easily be explained with the formation of 3-methylbenzoxathiane moieties, for compound 3 they result difficult to explain. The MIKE spectra of the ionic species at m/z 164 and m/z 165 originating from compound 2 are practically superimposable with those of the corresponding ions from 3. Hence the related fragmentation processes give rise to ions of identical structures.

For compound 2 the formation of ionic species at m/z 164 can be explained by the concerted losses of $COOC_2H_5^{\cdot}$ and $H^{\cdot}$, while for compound 3 they can be explained by the analogous concerted losses of $COOCH_3^{\cdot}$ and CH_3. Hence for the ions at m/z 164 originating from 2 and 3, it is reasonable to propose the structure of 2-methyl-1,4-benzoxathiane molecular ion.

The ions at m/z 165 easily originate from 2 by simple cleavage of the C(3)-CO bond, while for 3 the mechanism reported in scheme 5 can be proposed.



Scheme 5

In conclusion the title compounds do not seem to undergo EI induced isomerization processes. The presence of fragment ions of identical structure(s) must be ascribed to the high stability of the fragment itself.

EXPERIMENTAL

All the mass spectrometric measurements were performed on a VG-ZAB-2F instrument operating in EI conditions (70 eV, 200 µA). Samples were introduced via direct inlet system without any probe heating and with an ion source temperature of 200°C. Metastable transition were detected by B/E and B^2/E linked scans[7]. Accurate mass measurements were performed with the peak matching technique at 10.000 resolving power (10% valley definition). Mass Analyzed Ion Kinetic Energy (MIKE) spectra were obtained in the usual manner[8]. Compound 1 was analytically pure sample synthesized and purified according literature[9].

2-Methyl-3-carbethoxy-1,4-benzoxathiane 2

A mixture of 2-hydroxythiophenol (0.1 mole), 2,2-dibromoethylbutanoate (0.1 mole), anhydrous potassium carbonate (0.194 mole) and dry acetone (100 ml) was refluxed under a stream of nitrogen for 24 h. After cooling the mixture was filtered and the solid was washed with dry acetone. The solvent was then removed in a rotary evaporator and the residue was poured into water and extracted with diethylether. The ethereal layers was washed (in turn) with 10% aqueous sodium hydroxide, water and dried over anhydrous sodium sulfate. After solvent evaporation the crude product was chromatographed on a silica gel column using petroleum ether-diethyl ether 3:1 as eluent to give the compound 2; yield 58%, b.p./5 mm 172-175°C, n_D^{19} 1.5625; ir (neat) : 1740 cm^{-1} (C=O); ^{1}H-nmr ($CDCl_3$) δ : 1.15 (t, 3H, $\underline{CH_3}$-CH_2), 1.40 (d, 3H, $\underline{CH_3}$-CH-S-), 3.55 (m, 1H, CH_3-$\underline{CH_2}$-S), 4.10 (q, 2H, CH_3-$\underline{CH_2}$-), 4.60 (d, 1H, -O-$\underline{CH_3}$-COO) and 6.90 (m, 4H, Aromatic). Anal. Calcd. for $C_{12}H_{14}O_3S$: C, 60.48; H, 5.92; S, 13.45. Found: C, 60.42; H, 5.93; S, 13.41.

2,2-Dimethyl-3-carbomethoxy-1,4-benzoxathiane 3

This compound was prepared by the same procedure described for 2, starting from 2-hydroxythiophenol (0.1 mole), 3-methyl-2,3-dibromoethylbutanoate (0.1 mole) to give 3, yield 68%, b.p. /2 mm 136-138°C, n_D^{17} 1.5710, ir (neat) : 1745 cm^{-1} (C=O); ^{1}H-nmr ($CDCl_3$) δ : 1.45 (s, 6H, $(\underline{CH_3})_2$-C-S), 3.65 (s, 3H, -$COOCH_3$-), 4.50 (s, 1H, -O-CH-) and 6.85 (m, 4H, Aromatic). Anal. Calcd for $C_{12}H_{14}O_3S$: C, 60.48; H, 5.92; S, 13.45. Found : C, 60.45; H, 5.91; S, 13.43.

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