The Electron-impact Mass Spectra of 1,2-Benzisoxazole *N*-Oxides

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The mass spectra of a new class of heterocyclic *N*-oxides are reported. It is proposed that the fragmentation processes proceed either by an initial deoxygenation, and or an impact-induced isomerisation, prior to fragmentation. Substituents on the carbocyclic ring normally confer stability on the m olecular ions, whereas those on the heterocyclic ring open up additional fragmentation modes. A phenyl group at the 3-position allows an intramolecular oxygen transfer prior to fragmentation.

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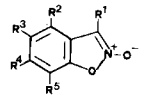
1,2-Benzisoxazole *N*-oxides constitute a new class of heterocyclic *N*-oxides. The synthesis and some aspects of the chemistry of a number of them have been previously reported [1]. In this paper we present and discuss the various features of these compounds revealed by the fragmentation pattern in their mass spectra. We observed that the presence of substituents on the heterocyclic ring cause considerable differences in the fragmentation pattern and affect the pathways along which these molecules break down. The compounds studied are listed in Table 1.

Table 1

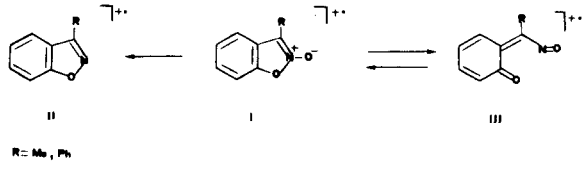


Compound No.	R^1	R^2	R^3	R^4	R^5
1	Me	H	H	H	H
2	Me	H	Br	H	H
3	Me	H	Br	H	Br
4	Me	H	Me	H	H
5	Me	H	Cl	H	H
6	Me	H	NO_2	H	H
7	Me	H	H	NO_2	H
8	Me	H	NO_2	H	NO_2
9	Me	H	H	OMe	H
10	Ph	H	H	H	H
11	Ph	H	Cl	H	H
12	Ph	H	Me	H	H
13	Ph	H	H	OMe	H
14	PH	NO_2	H	NO_2	H
15	Ph	H	Br	H	Br

Prominent peaks at m/z values corresponding to the molecular ions of the title compounds were observed. The relative intensities of the molecular ion peaks varied with the presence of substituents. In addition to the molecular ion peaks, the fragmentation pattern of this class of compounds is characterized by appearance of peaks at m/z values $[M-16]^+$ and $[M-30]^+$. These peaks are attributed to the loss of an oxygen atom, and of a nitroso group, from the molecular ion, respectively. Generally the $[M-16]^+$ peak is of low intensity, lower than that of the parent ion. The $[M-16]^+$ fragment has also been observed in the spectra of other heteocyclic *N*-oxides [2]. Its presence is of diagnostic value in the characterisation of such compounds. In the present study its intensity ranges from low to medium. The $[M-30]^+$ fragment is more abundant with intensity ranging from medium to high. A similar pattern was observed in the spectra of furazan *N*-oxides [3] which tend to favour the loss of the m/z = 30 group rather than the oxygen atom.

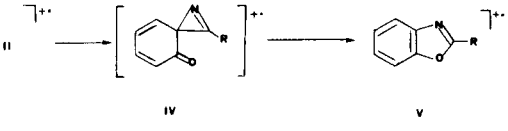
The loss of oxygen ($[M-16]^+$) and the $[M-30]^+$ fragment were considered as the initial stages of the rupture of these molecules. These could be accounted for by an initial deoxygenation to II through scission of the exocyclic N-O bond, and an impact-induced isomerization to III (Scheme 1) and subsequent loss of NO fragment.

Scheme 1



The deoxygenated species II may either fragment further or it may undergo ring isomerization rearrangement to the oxazole V prior to fragmentation (Scheme 2). The intermediacy of an azirine ring IV is highly likely as it has been reported [4-6] in the photochemically-induced isomerization of II to V.

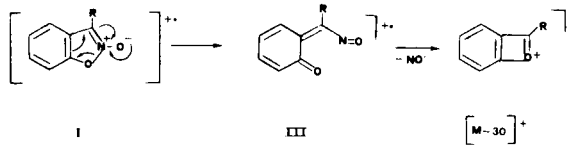
Scheme 2



The loss of a nitroso group is believed to proceed through an impact-induced rearrangement of I to its valence bond isomer III (Scheme 3). The cleavage of the

heterocyclic N-O bond has been found experimentally [1] to proceed quite easily. This is in accordance with the difference in the estimated strengths of the exocyclic and the ring N-O bonds. Viterbo and Chiari [4] have determined by X-ray crystallography that the exocyclic N-O bond length is 124.7 pm, which compares with that of a nitro group. On the other hand, the ring N-O bond is quite lengthened (146.8 pm) and compares with the most strained bonds found in the closest analogues of this class, the fused furazan *N*-oxides [8]. The nitroso isomer III expels a nitroso group thus giving rise to the $[M-30]^+$ peak.

Scheme 3



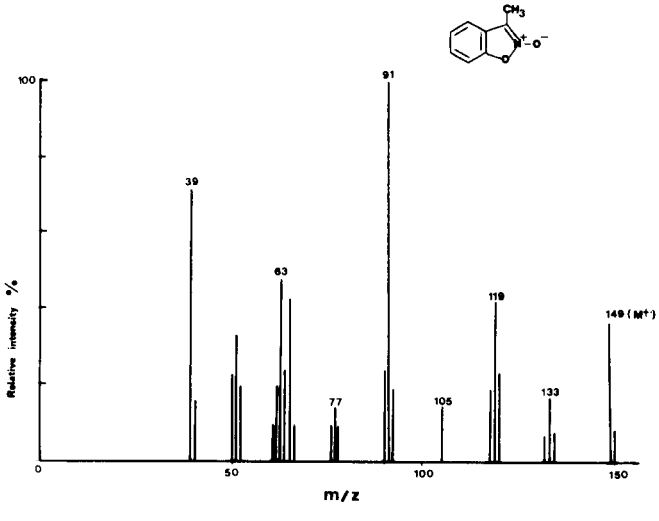
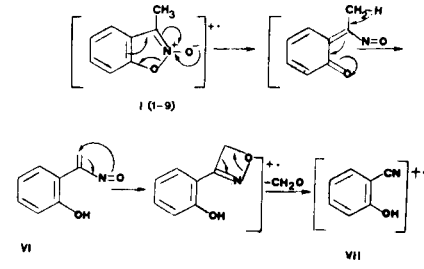


Figure 1. Mass spectrum of 3-methyl-1,2-benzisoxazole *N*-oxide.

The presence of substituents in the heterocyclic ring offers the possibility of alternative pathways for fragmentation. Thus a methyl group in C-3 creates a third fragmentation route (Scheme 4).

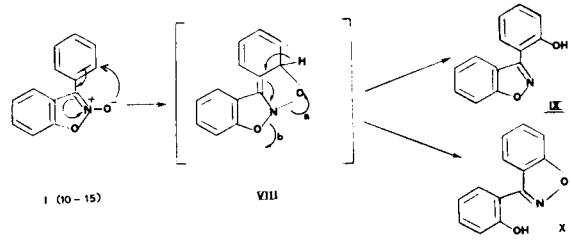
Scheme 4



Support for the plausibility of this mechanism comes from the photochemical conversion [9] of 1,2-benzisoxazole to 2-cyanophenol VII as well as from accurate mass measurements. The fragment arising from the loss of CH_2O is about 20 times less intense than that resulting from the loss of NO. The proposed mechanisms are consistent with the mass spectrum and fragmentation pattern of 3-methyl-1,2-benzisoxazole *N*-oxide **1** (Figures 1 and 2).

The mechanism proposed in Scheme 4 is no longer applicable when a phenyl replaces the methyl group in C-3. However, the appearance of fragments resulting from the loss of PhCNO, HNCO, HCN and CO from the parent ion

Scheme 5



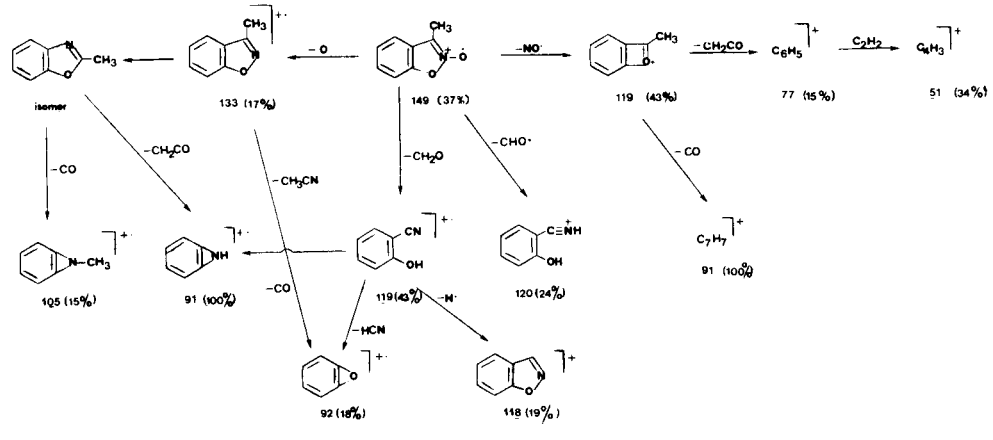


Figure 2. Proposed pathways for the fragmentation of 3-methyl-1,2-benzisoxazole *N*-oxide.

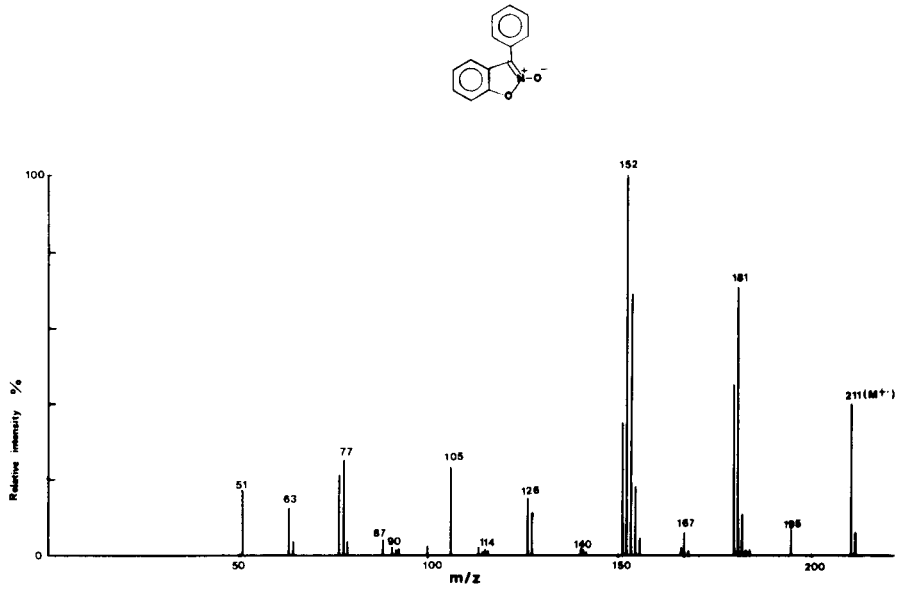


Figure 3. Mass spectrum of 3-phenyl-1,2-benzisoxazole *N*-oxide.

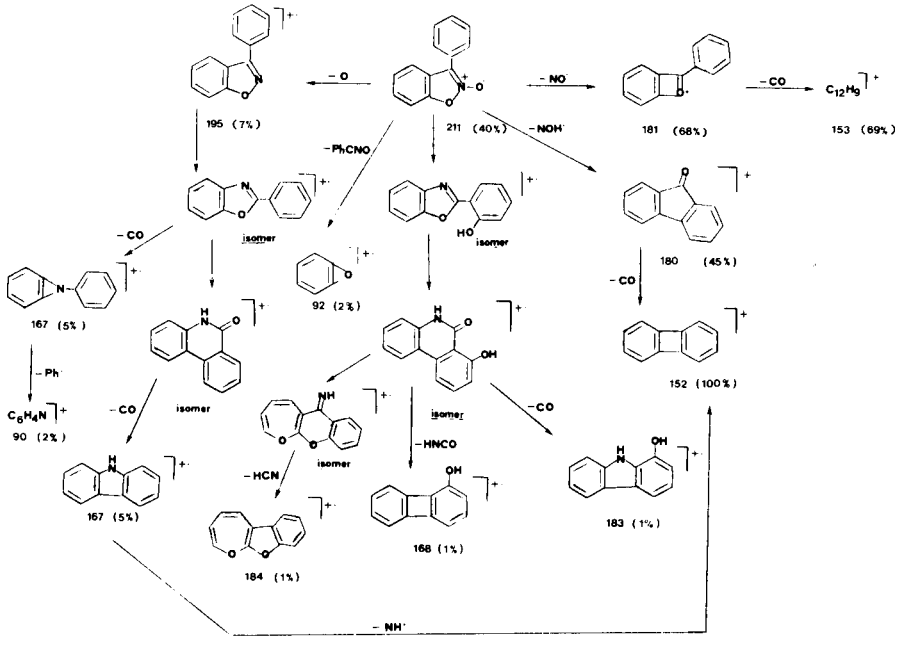


Figure 4. Proposed pathways for the fragmentation of 3-phenyl-1,2-benzisoxazole *N*-oxide.

(Figure 3 and 4) suggest that additional fragmentation pathways, involving rearrangements, are operative for the 3-phenyl-1,2-benzisoxazoles.

For the 3-phenyl derivatives arises the possibility of the mechanism depicted in Scheme 5.

This mechanism involves an isomerization of the *N*-oxide to compounds IX and X and results in an overall intramolecular oxygen transfer. This proposal is supported by precedents suggested [10] to explain the photochemically induced Wallach rearrangement. Clearly the isomers IX and

Table 2

Fragment Ions in the Mass Spectra of 1,2-Benzisoxazole *N*-Oxides

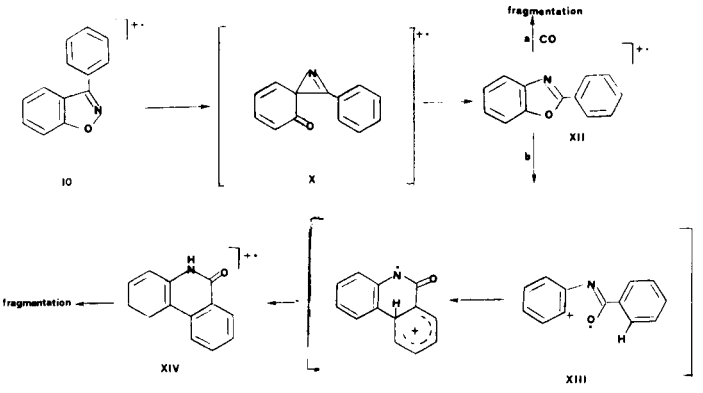
Compound	
1	149 (37) [a] M$^+$, 134 (8),133 (17), 132 (9), 120 (24), 119 (43), 118 (19), 105 (15), 92 (18), 91 (100), 90 (24), 78 (10), 77 (15), 76 (10), 69.6* [119-91] [b], 66 (10), 65 (43), 64 (24), 62 (10), 52 (20), 51 (33), 50 (25), 40 (14), 39 (72)
2	229 (36) [c] M$^+$, 213 (7), 199 (24), 171 (12), 145 (5), 144 (2), 118 (100), 92 (3), 90 (55), 74 (7), 64 (17), 63 (54), 62 (23), 61 (100)
3	307 (55) [c] M$^+$, 291 (9), 278 (68), 266 (9), 249 (8), 238 (8), 229 (8), 198 (81), 169 (38), 167 (35), 118 (27), 89 (100), 63 (79)
4	163 (41) M$^+$, 147 (19), 136 (4), 133 (46), 118 (24), 105 (100), 91 (17), 90 (23), 76 (12), 64 (5)
5	183 (32) [c] M$^+$, 167 (8), 153 (27), 139 (16), 125 (100), 118 (72), 90 (12), 76 (23), 64 (31)
6	194 (61) M$^+$, 178 (5), 165 (33), 164 (57), 163 (46), 147 (12), 145 (12), 138.6* [194-164], 135 (8), 119 (12), 118 (100), 117 (36), 105 (7), 91 (28), 90 (93), 89 (77), 79 (12), 78 (15), 77 (17), 68.6* [118-90], 65 (19), 64 (37), 63 (72), 62 (31)
7	194 (78) M$^+$, 178 (11), 165 (40), 164 (55), 163 (100), 150 (6), 147 (22), 135 (6), 121 (6), 120 (6), 119 (12), 118 (50), 105 (12), 91 (24), 90 (50), 89 (69), 77 (11), 76 (24), 63 (67), 51 (29), 50 (16)
8	239 (13) M$^+$, 223 (4), 211 (62), 209 (8), 184 (8), 181 (79), 167 (10), 166 (100), 165 (13), 155.2* [211-181], 149 (26), 120 (50), 119 (22), 105 (12), 92 (24), 91 (19), 79 (11), 78 (8), 77 (16), 63 (31)
9	179 (58) M$^+$, 163 (10), 150 (73), 149 (100), 148 (75), 134 (21), 133 (53), 121 (96), 120 (17), 98.2* [149-121], 91 (39), 90 (13), 89 (21), 79 (19), 78 (36), 77 (72), 76 (12), 64 (9), 63 (33), 62 (15)
10	211 (40) M$^+$, 195 (7), 182 (12), 181 (68), 180 (45), 154 (18), 153 (69), 152 (100), 151 (35), 127 (13), 126 (15), 105 (23), 104.4* [152-126], 77 (25), 76 (21), 63 (12)
11	245 (23) [c] M$^+$, 229 (11), 215 (47), 210 (3), 201 (5), 180 (4), 167 (4), 162.6* [215-187], 152 (100), 151 (24), 150 (9), 141 (5), 126 (15), 105 (40), 77 (28), 75 (16)
12	241 (33) M$^+$, 225 (12), 211 (100), 196 (15), 183 (10), 182 (16), 181 (10), 180 (10), 168 (52), 158.7* [211-183], 152 (32), 138 (53), 126 (13), 105 (14), 77 (24), 76 (17), 75 (13)
14	301 (33) M$^+$, 285 (21), 271 (61), 270 (29), 225 (13), 224 (8), 212 (8), 198 (18), 197 (100), 196 (11), 167 (16), 165 (15), 151 (65), 150 (95), 126 (9), 125 (16), 105 (14), 77 (23), 76 (21), 75 (34), 74 (21), 63 (29), 51 (23), 50 (15)
15	369 (6) [c] M$^+$, 353 (2), 341 (9), 339 (18), 262 (4), 260 (18), 258 (18), 232 (28), 230 (29), 176 (6), 151 (89), 150 (100), 126 (22), 105 (36), 91 (14), 77 (59)

[a] Numbers in parentheses indicate % relative abundances. [b] Numbers in brackets indicate transitions. [c] Abundance of the most intense isotopic peak.

X would be identical in the case of **10**.

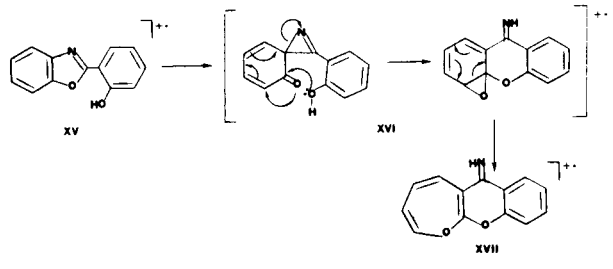
The fragmentation of compounds IX, X (Scheme 5) and of the deoxygenated species of I is expected to proceed along similar pathways since they have in common the benzisoxazole skeleton. This is illustrated for **10** (Scheme 6).

Scheme 6



The ring isomerization rearrangement and route **a** are similar to those proposed for the methyl analogue of the deoxygenated species. An alternative minor fragmentation route is envisaged (Scheme 7) arising from the presence of the -OH group. Ths pathway involves ring expansion XVII as shown in Scheme 7.

Scheme 7



The mass spectrum and fragmentation pattern of 3-phenyl-1,2-benzisoxazole *N*-oxide **10** (Figures 3 and 4) exemplify the mechanisms proposed.

The substituents attached to the carbocyclic ring do not seem to influence the skeletal fragmentation while it appears that they affect the relative stability of the various fragments, as indicated by their relative intensities (Table 2). The effect is more pronounced in those compounds having substituents with strong electronic effects *i.e.* **6-9**, **13** and **14**.

Metastable ions were observed in some of the spectra. The transitions that give rise to their appearance are also listed in Table 2.

EXPERIMENTAL

The mass spectra were obtained on a Hitachi-Perkin-Elmer Model RMU-6L spectrometer. Samples were analysed in the temeprature range 120-200° by a direct insertion probe at an ionization voltage of 70 eV. The substittued 1,2-benzisoxazole *N*-oxides were prepared as previously reported [1].

Acknowledgements.

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