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MASS SPECTROMETRY IN STRUCTURAL AND STEREOCHEMICAL PROBLEMS—CLXXIV:[1]

ELECTRON-IMPACT INDUCED FRAGMENTATION OF SOME ARYL- AND ALKYLSULFONYLTHIOUREAS

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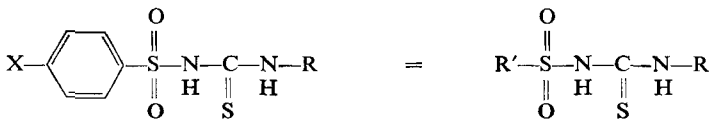
Abstract—The mass spectra of five aryl (I to V) and four alkylsulfonylthioureas (VI to IX) have been recorded and mechanistic rationalizations are suggested for their principal fragmentation processes. The aryl analogs exhibited peaks in their mass spectra corresponding to skeletal rearrangements with elimination of SO_2 from their molecular ions but this fragmentation was absent in those alkylsulfonylthioureas (VI to IX) examined.

ONE ASPECT of organic mass spectrometry which has received considerable attention over the past few years is the question of molecular rearrangement processes and a comprehensive review has recently appeared.[2] Typical of such rearrangements is the loss of SO_2 from sulfonamides,[3,4] sulfonyl chlorides,[4] sulfonylhydrazones[5] and sulfonylureas.[6] In view of the distinct behavior on electron-impact of ureas[7] and thioureas[8] and also between semicarbazones[9] and thiosemicarbazones[10] it was of interest to examine in detail the mass spectra of sulfonylthioureas with particular reference to the scope and magnitude of any elimination of SO_2 observed from the molecular ions of these compounds. In the sequel we wish to describe the major fragmentation modes subsequent to electron-impact of this hitherto uninvestigated class of compound.

DISCUSSION OF MASS SPECTRA



(I) R = C_6H_5; X = H
(II) R = C_6H_5; X = CH_3
(III) R = CH_3; X = H
(IV) R = C_2H_5; X = H
(V) R = n-C_3H_7; X = H

(VI) R = C_2H_5; R′ = CH_3
(VII) R = C_2H_5; R′ = n-C_3H_7
(VIII) R = n-C_4H_9; R′ = n-C_3H_7
(IX) R = C_6H_5; R′ = CH_3

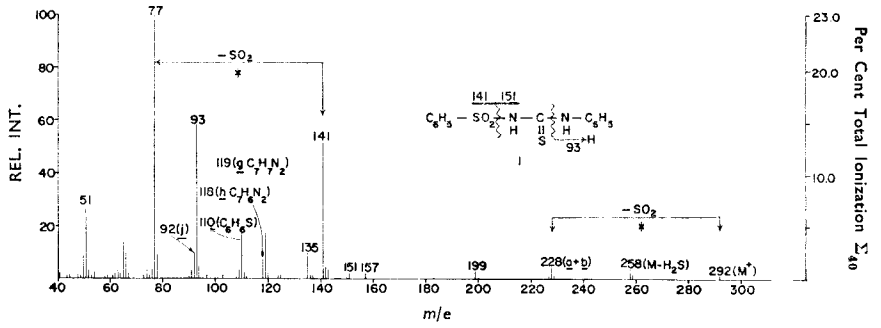


FIG. 1. Mass spectrum (70 eV) of 1-(phenylsulfonyl)-3-phenylthiourea.

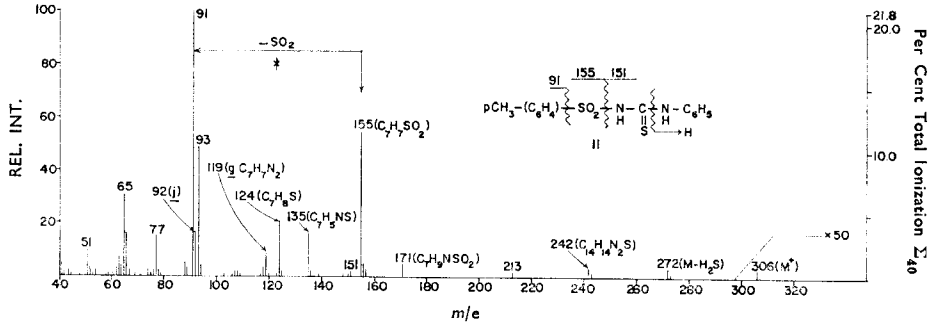


FIG. 2. Mass spectrum (70 eV) of 1-(*p*-toluenesulfonyl)-3-phenylthiourea.

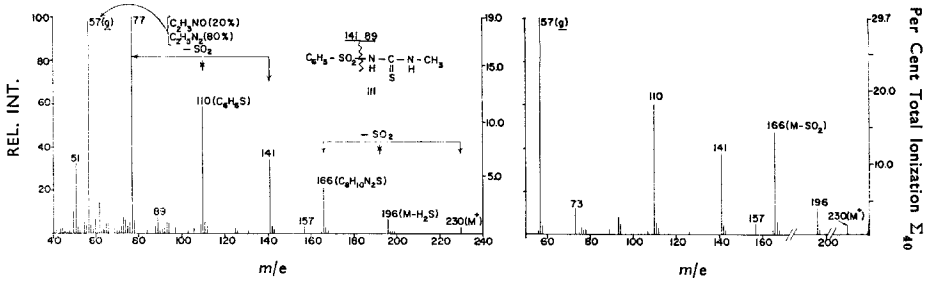


FIG. 3. Mass spectrum (70 eV) of 1-(phenylsulfonyl)-3-methylthiourea.

FIG. 3a. Mass spectrum (12 eV) of 1-(phenylsulfonyl)-3-methylthiourea.

This investigation deals with the mass spectra (Figs. 1 to 9) of five aryl- (I to V) and four alkylsulfonylthioureas (VI to IX). It is apparent (Figs. 1 to 9) that the molecular ion of alkyl sulfonylthioureas (VI to IX) is relatively more stable than that of the aryl sulfonyl analogs studied. All the compounds investigated except for VII and VIII showed a loss of hydrogen sulfide from their parent ion to generate the fragment of highest mass. This behavior should be contrasted with the situation prevailing in substituted 3-phenylthioureas[8] in which electron-impact (using a cool (70°) ion source) causes only elimination of a sulfhydryl radical while under pyrolytic conditions[8] hydrogen sulfide is ejected. Other investigators[11] report the loss of hydrogen sulfide from thioureas on electron-impact.* It would seem that the loss of hydrogen sulfide

* This loss is now known to be thermal (Private Communication, A. G. Loudon).

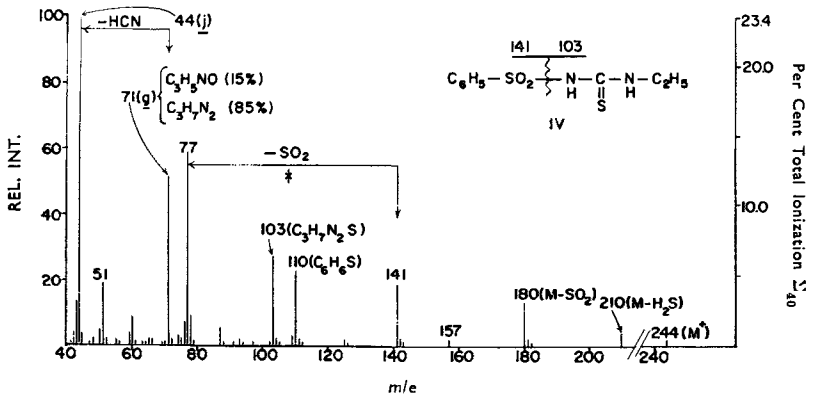


FIG. 4. Mass spectrum (70 eV) of 1-(phenylsulfonyl)-3-ethylthiourea.

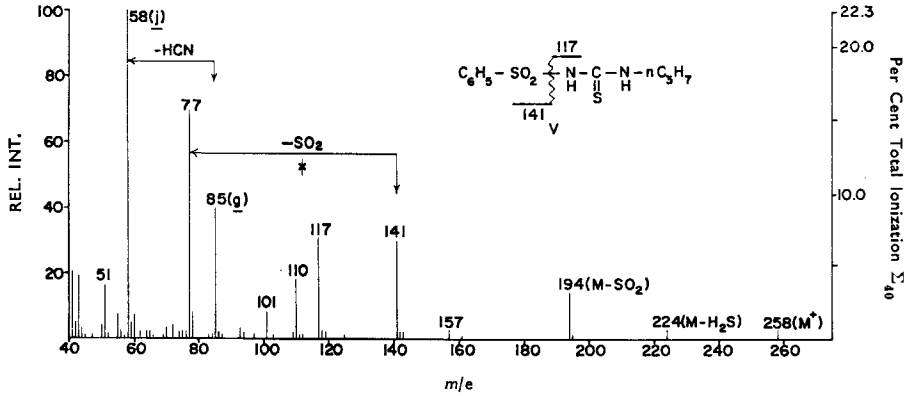


FIG. 5. Mass spectrum (70 eV) of 1-(phenylsulfonyl)-3-n-propylthiourea.

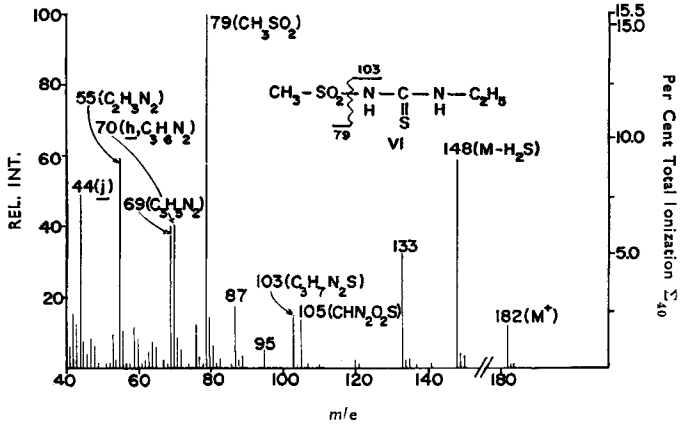


FIG. 6. Mass spectrum (70 eV) of 1-(methylsulfonyl)-3-ethylthiourea.

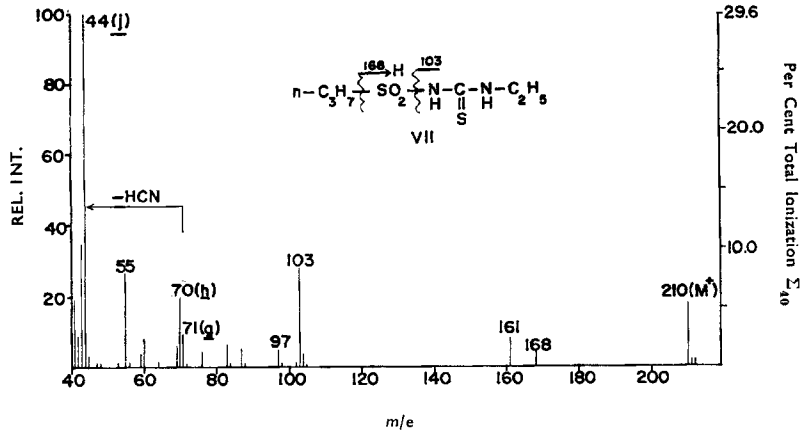


FIG. 7. Mass spectrum (70 eV) of 1-(n-propylsulfonyl)-3-ethylthiourea.

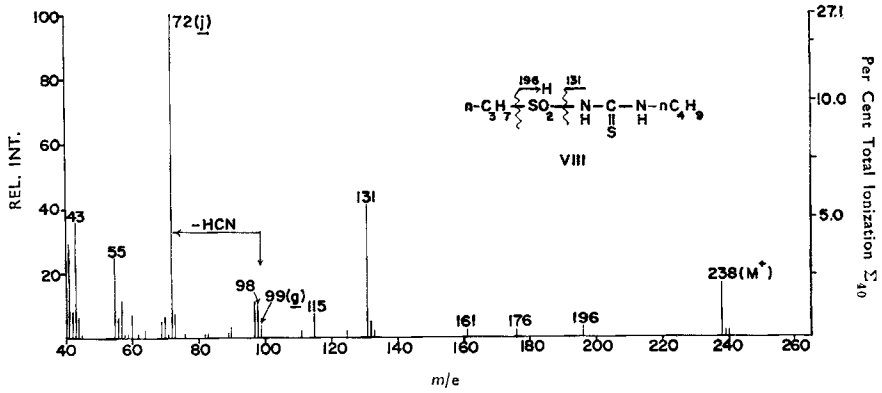


FIG. 8. Mass spectrum (70 eV) of 1-(n-propylsulfonyl)-3-n-butylthiourea.

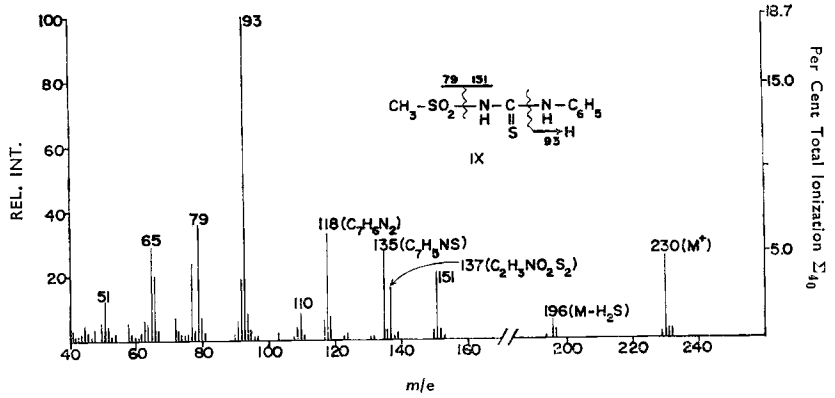
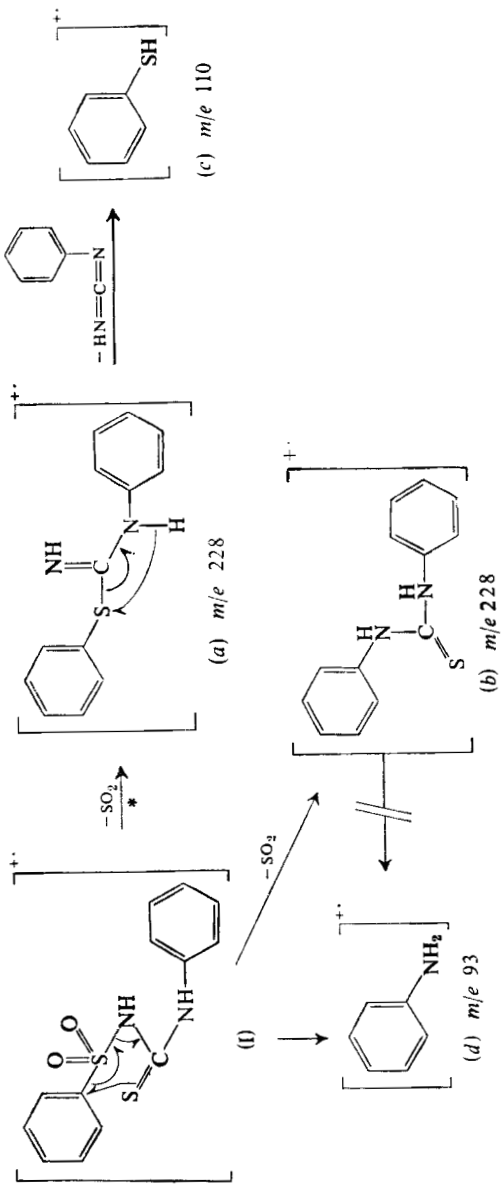


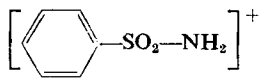
FIG. 9. Mass spectrum (70 eV) of 1-(methylsulfonyl)-3-phenylthiourea.


(a) m/e 228
(b) m/e 228
(c) m/e 110
(d) m/e 93
(I)
$-SO_2$
$-SO_2$
$-H_2N{=}C{=}N$

from these compounds may be thermal in nature. The mass spectra reported in this communication were obtained with direct sample insertion into an ion source maintained at 180° in contrast to the previous study of thioureas[8] which utilized a 70° ion source temperature. In an attempt to minimize thermal fragmentation the mass spectrum of V was repeated using a molecular beam inlet system.[12] In this instance the peak due to the expulsion of H_2S from the parent ion amounted to one third of the abundance of the molecular ion compared to the equal intensities recorded in Fig. 5.

The five arylsulfonylthioureas (I to V) each contain a peak (Figs. 1 to 5) due to the elimination of SO_2 from their respective molecular ions. It should be noted that the four alkyl derivatives (VI to IX; Figs. 6 to 9) lack this fragmentation. Furthermore, the expulsion of SO_2 from I to V increased at low ionizing voltages (12 eV) (see for instance Fig. 3a) and was accompanied by the presence of a metastable ion. Mechanistically this molecular rearrangement can be rationalized by I → *a* or I → *b*. Subsequent decomposition of *a* by the elimination of phenylcarbodiimide (no metastable ion was recognized) would yield formally the equivalent of ionized thiophenol (*c*, *m/e* 110) and the latter's composition (C_6H_6S) was verified for this ion by high resolution mass measurement. This affords some indirect evidence for the existence of ion *a*. In the mass spectrum (Fig. 2) of the *p*-tolyl analog the ion corresponding to *c* was located at mass 124 and had the composition C_7H_8S. Similarly, decomposition of *b* could yield the equivalent of ionized aniline *d* (*m/e* 93) but this species would also be expected to arise directly from the molecular ions of the N-phenyl sulfonylthioureas investigated. In the low voltage spectra (12 eV) of compounds I, II and IX the base peak was located at *m/e* 93 thus affording strong evidence in favor of the species equivalent to *d* arising directly from the molecular ion rather than the fragment ion *b*. It should be noted that ions analogous to *a* and *b* have been invoked[6] to rationalize the loss of SO_2 from the molecular ion of N-*n*-butylsulfonylurea.

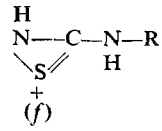
Weak peaks at *m/e* 157 (*m/e* 171 in the case of II) occur in the spectra of the arylsulfonylthioureas (I to V) and can be rationalized in terms of *e*. It is noteworthy that this fragmentation is not present in the alkylsulfonylthioureas (VII and VIII) but is represented by weak peaks in the mass spectra (Figs. 6 and 9) of the two methylsulfonylthioureas (VI and IX) investigated.



(*e*) *m/e* 157

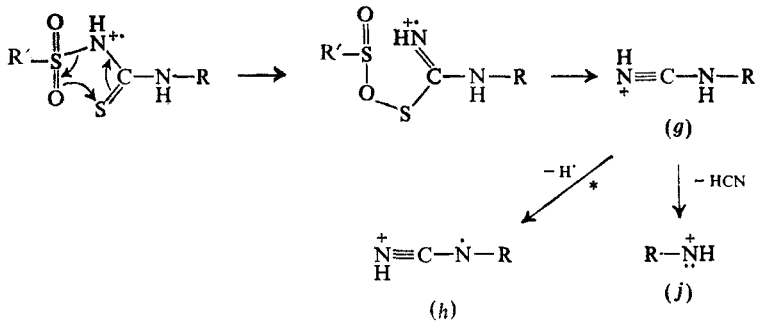
Abundant ions at mass 141 in the arylsulfonylthioureas I, III to V correspond to $C_6H_5SO_2$ by high resolution mass measurement (*m/e* 155 and $C_7H_7SO_2$ in the case of II) and are formed by rupture of a benzylic bond. This cleavage is strongly represented in the case of the methylsulfonyl derivatives (*m/e* 79 in Figs. 6 and 9) but is virtually non-existent in the other alkyl derivatives (VII and VIII) investigated.

The expulsion of $ArSO_2\cdot$ from the molecular ions of compounds I to V is an unfavorable process but in the alkyl analogs (VI to IX) the loss of $R'SO_2\cdot$ accounts for the formation of relatively abundant ions (see *m/e* 103 in Figs. 6 and 7; *m/e* 131 in Fig. 8 and *m/e* 151 in Fig. 9). Formally such a cleavage product could be represented as *f* but there exists, of course, no evidence that rearrangement to a noncyclic structure did not occur.



(*f*)

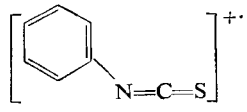
A particularly interesting fragmentation, common to all of the sulfonylthioureas investigated, corresponds to the loss of $ArSO_2^{\cdot}$ or $R'SO_2^{\cdot}$ plus the thione sulfur atom from their respective molecular ions (see for instance *m/e* 119 in Figs. 1 and 2; *m/e* 57 in Fig. 3; *m/e* 71 in Fig. 4, *m/e* 85 in Fig. 5) as shown by the appropriate high resolution mass measurements in a number of instances. We represent this species as *g* which often further fragments by the expulsion of a hydrogen atom to afford *h* (metastable ions recognized in many instances). An alternative fragmentation pathway of *g* could occur by the extrusion of HCN (formation of *j*) which would stabilize itself by an intramolecular hydrogen shift. However, no metastable ions were observed to substantiate this origin of *j*.



(*g*) (*h*) (*j*)

The expulsion of the thione sulfur atom in the genesis of *g* has a precedent in the elimination of one, two and four sulfur atoms from the molecular ions of thiuram-disulfides.[13] It should be noted that the product ion *g* of this molecular rearrangement is enhanced in those arylsulfonylthioureas in which R′ corresponds to an alkyl radical (see *m/e* 57 in Fig. 3; *m/e* 71 in Fig. 4 and *m/e* 85 in Fig. 5) and it should be noted that these peaks are the most abundant present in the low voltage (12 eV) spectra (*m/e* 57 in Fig. 3a).

Those sulfonylthioureas studied which contain an N-phenyl entity (I, II and IX) all have a common ion (*k*) of mass 135 in their spectra. The formulation *k* has been used to rationalize the presence of a relatively abundant ion observed in the mass spectra[8] of a number of 1,1-disubstituted 3-phenylthioureas. This species was virtually absent, however, from the spectra of 1-substituted 3-phenylthioureas.[8]



(*k*) *m/e* 135

In summary two molecular rearrangement processes, one involving loss of SO_2 from arylsulfonylthioureas and the other requiring the elimination of $ArSO_2$ and RSO_2

plus the thione sulfur atom from aryl and alkylsulfonylthioureas have been shown to occur in the electron-impact induced fragmentation of these compounds. The remainder of the principal fragmentation pathways involved simple bond cleavage with and without hydrogen transfer.

EXPERIMENTAL

Mass spectra were obtained by Mr R. G. Ross of Stanford University using direct sample insertion into the ion source (temperature 180°) of an MS-9 mass spectrometer. High resolution mass measurements were accurate to within 3 ppm and are indicated in terms of empirical formulae on the reproduced mass spectra.

Samples used in this investigation were of analytical purity and were synthesized[14] by the following general procedure.

Preparation of N-Sulfonylthioureas. To a solution of 0·1 M of the corresponding sulfonamide and 4 g of sodium hydroxide in water (75 ml) was added a solution of 0·1 M of the appropriate alkyl isothiocyanate in acetone (40 ml). The reaction mixture was maintained at 60° for 15 hrs. The crystals were removed by filtration and the filtrate acidified and the crude product crystallized several times from ethanol.[15] The following compounds have not been reported previously. III; m.p. 130–1°; (Found C, 41·5; H, 4·3; N, 12·0. $C_8H_{10}N_2S_2O_2$ requires C, 41·7; H, 4·4; N, 12·2%); IV, m.p. 117–9° (Found C, 44·3; H, 4·9; N, 11·2. $C_9H_{12}N_2S_2O_2$ requires 44·3; H, 5·0; N, 11·5%).

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