Rearrangements in the Molecular Ion of *o*-(Methyl-d_3-thio)benzoic Acid:

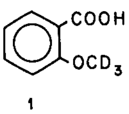
Comparison with *o*-Methoxy-d_3-benzoic Acid†

Richard G. Gillis‡ and Quentin N. Porter
Department of Organic Chemistry, University of Melbourne, Parkville; Victoria 3052, Australia

Hydrogen/deuterium exchange and rearrangements in the molecular ion of *o*-(methyl-d_3-thio)benzoic acid lead to fragment ions $[M-OD]^+$ as well as $[M-OH]^+$ and *m/z* 106 and 107, just as in the molecular ion of *o*-methoxybenzoic acid. However, the fragment ion *m/z* 108 has the composition C_6H_4S rather than $C_6H_2D_3CO$ as it does in the case of *o*-methoxy-d_3-benzoic acid. By varying the repeller potential at 10 eV (and thus the residence time in the ion source), the corresponding fragments are seen to be formed more slowly from the methylthio acid than from the methoxy acid, which leads to the conclusion that H/D exchange between carboxyl and labelled methylthio is slower than it is between carboxyl and labelled methoxyl.

INTRODUCTION

The molecular ion of *o*-trideuteromethoxybenzoic acid (**1**) undergoes hydrogen/deuterium exchange between the methoxy and carboxy groups. This is followed by three different rearrangements which lead to fragment ions at *m/z* 105, 106 and 107.[1] It then becomes of interest to examine the behaviour of the sulphur analogue *o*-(trideuteromethylthio)benzoic acid (**2**).



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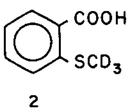

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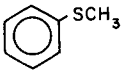

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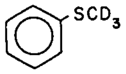

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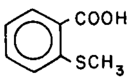

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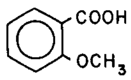

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Bowie *et al.*, in their study of aromatic thio ethers,[2] compared the mass spectra of thioanisole (**3**) and thioanisole-methyl-d_3 (**4**). In **3** they observed ions at *m/z* 109 $[M-CH_3]^+$, *m/z* 91 $[M-SH]^+$, and *m/z* 78 $[M-CH_2S]^{+\cdot}$; metastable transitions confirmed the formation of *m/z* 91 and 78 directly from the molecular ion. In the spectrum of **4** they observed ions at *m/z* 109 $[M-CD_3]^+$, *m/z* 94 $[M-SH]^+$, *m/z* 93 $[M-SD]^+$ and *m/z* 79 $[M-CD_2S]^{+\cdot}$. The formation from the molecular ion of *m/z* 94 and 93 only was confirmed by metastable peaks. After detailed comparison, they concluded 'our results exclude any rearrangement which would involve reciprocal hydrogen transfers between the methyl group and the aromatic nucleus'. We understand this to mean that no exchange takes place in thioanisole such as Meyer and Harrison found in anisole-methyl-d_3.[3] Tatematsu *et al.* independently reached the same conclusion.[4]

Another difference between anisole and thioanisole is that anisole does not lose $^\cdot OH$[5] in the way that thioanisole loses $^\cdot SH$. Anisole does have comparable decompositions giving $[M-CH_3]^+$ and $[M-CH_2O]^{+\cdot}$ fragments.

Bowie *et al.*[2] also reported the mass spectrum of *o*-(methylthio)benzoic acid (**5**) on which they performed a similar experiment to that which Ramana and Sundaram[6] performed on *o*-methoxybenzoic acid (**6**), i.e. they reacted the acid with D_2O in the ion source forming $CH_3SC_6H_4COOD$ and observed in the spectrum ions of composition $[M-CH_3]^+$ and $[M-CH_2D]^+$, from which they concluded that 'the deuterium . . . is not retained solely in the carboxyl group after ionization; it appears to be partially scattered in the *S*-methyl group . . . and . . . into the vacant *ortho* position of the aromatic ring'.

To compare the rearrangements in **2** with those in **1**, we have examined their mass spectra at 10 eV and varying repeller potentials, i.e. different residence times in the ion source.

RESULTS AND DISCUSSION

Our 70 eV spectrum of **5** matched that of Bowie *et al.*[2] almost exactly, except for *m/z* 124 $[M-44]^+$, which had an intensity of 2% of the base peak against their 40%, and *m/z* 45, 31% against their 17%.

Our 70 eV results for **2** follow; only peaks > 5% are listed: *m/z* (intensity), 171 ($[M]^{+\cdot}$) (100), 154(29), 153(24), 152(8), 151(5), 138(9), 137(18), 136(5),

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‡ Author to whom correspondence should be addressed.

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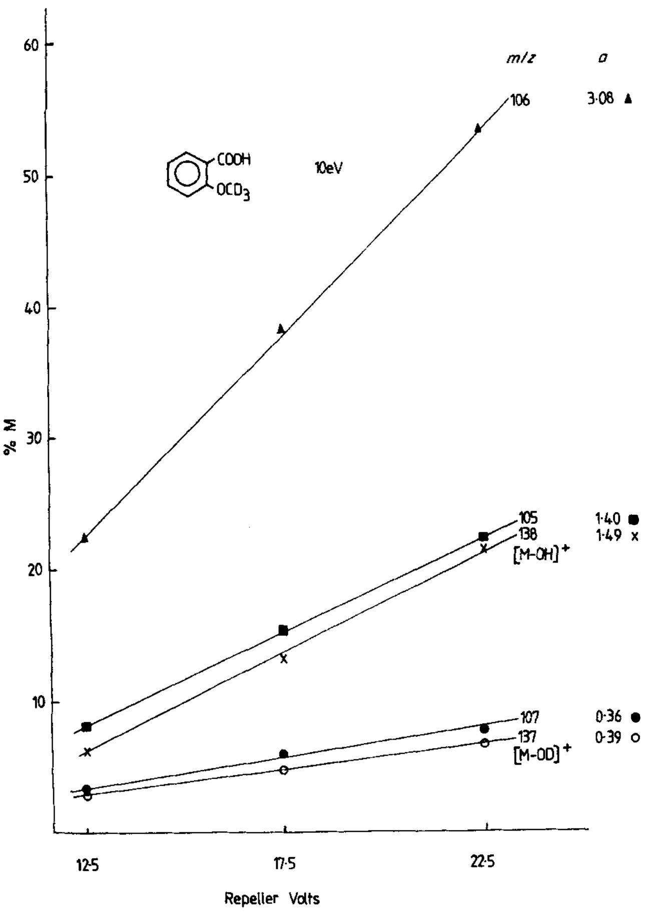

Figure 1. Fragment ion intensities in *o*-methoxy-d_3-benzoic acid at 10 eV v. repeller voltage. See text for symbols.

124(17), 123(16), 122(19), 109(7), 108(13), 106(12), 105(6), 97(6), 82(6), 80(8), 79(8), 78(10), 77(5), 76(7), 69(14), 65(6), 63(9), 51(8), 50(12), 46(16), 45(15), 39(9).

The 10 eV data for **1** are plotted against repeller voltage in Fig. 1, and for **2** in Fig. 2. On the right side of each figure are shown the *m/z* values of each fragment ion, its assignment and the value of *a* in the least squares fit of the data to the line

$$y = ax + b$$

where y is the intensity of the fragment ion relative to the molecular ion (100%) and *x* is the repeller potential. In principle *a*, the slope of this line, is a measure of the rate of formation of the fragment ion. In this discussion, it is used only semiquantitatively: if one line is steeper than another, it is concluded that the one fragment ion is formed faster than the other.

From Fig. 1 it is clear that the fragment ion *m/z* 106 is formed faster than any other from **1**. The fragment ion *m/z* 138 $[M-OH]^+$, is formed faster than *m/z* 137 $[M-OD]^+$, since H/D exchange is necessary before $^{\cdot}OD$ can be lost. In this case the assignment of the *m/z* 138 and 137 peaks to $[M-OH]^+$ and $[M-OD]^+$ is not confused by isobaric species. This conclusion is based on the spectrum of the unlabelled analogue **6** which does not lose $^{\cdot}CH_3$ but does lose $^{\cdot}OH$ to a significant extent (32%) and H_2O in a minor way (7%).[6] The relative rates of formation of the fragment ions *m/z* 106, 105 and 107 decrease in that order, which is explicable in terms of the H/D exchanges and the rearrangements which must occur before their precursors are formed in the ion source.

From Fig. 2 it can be seen that in **2** the fragment ion *m/z* 106 is formed faster than *m/z* 105 although both are formed much more slowly than the same fragments from **1**. However, the assignment of $[M-OH]^+$ and $[M-OD]^+$ is not as clear as in **1**. The unlabelled analogue **5** loses $^{\cdot}CH_3$ significantly (32%); it also loses $^{\cdot}OH$ (14%) and H_2O (16%)[2]. It follows that *m/z* 153 from **2** is not entirely $[M-OD]^+$; it must include isobaric components due to $[M-CD_3]^+$ and $[M-H_2O]^{+\cdot}$. Although the slope of the line for *m/z* 154 is only marginally steeper than that for *m/z* 153, it is clear that loss of $^{\cdot}OH$ from the molecular ion of **2** is faster than loss of $^{\cdot}OD$, as it was in the case of **1**.

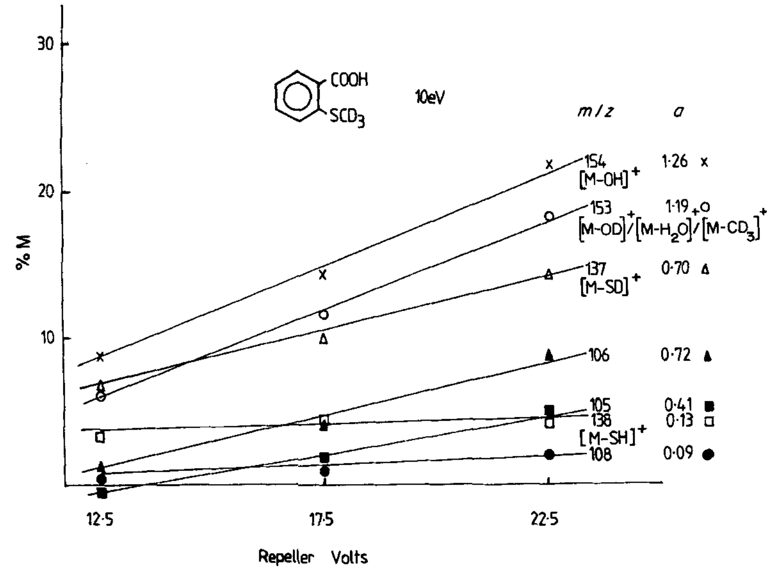

Figure 2: Fragment ion intensities in *o*-(methyl-d_3-thio)benzoic acid at 10 eV v. repeller voltage. See text for symbols.

Fragment ions of composition $[M-SH]^+$ and $[M-SD]^+$ are seen at *m/z* 138 and 137, respectively. The former is formed more slowly: it must arise from H/D exchange leading to —SCD_2H from which there is only one chance in three that ˙SH can be lost. The fragment ion *m/z* 108 is formed very slowly indeed; its composition is not $[C_6H_2D_3CO]^+$ as in the mass spectrum of **1** but $[C_6H_4S]^{+\cdot}$, since high-resolution measurement showed a singlet at mass 108.0031; C_6H_4S requires 108.0032. In the mass spectrum of **1** the corresponding ion $[C_6H_4O]^{+\cdot}$, *m/z* 92, is moderately intense ((27%),[6] (35%)[7] and (33%)[8]).

The rate-limiting step in the formation of the labelled fragment ions is H/D exchange between the methoxy and carboxy groups. Whenever the reactions which follow, i.e. (i) loss of ˙OH or ˙OD, (ii) exchange with the ring hydrogen *ortho* to the carboxy group, (iii) exchange with the ring hydrogen *ortho* to the methoxy group or (iv) *ipso* rearrangement of the methoxy or methylthio groups with loss of the elements of formaldehyde or thioformaldehyde, can be compared directly, the fragment ion is formed more slowly from **2** than from **1**.

EXPERIMENTAL

Thiosalicylic acid (B.D.H. 95%) was used to prepare **2** by reaction with CD_3I and sodium hydroxide in dimethyl sulphoxide[9] and subsequent alkaline hydrolysis of the ester thioether. It had a melting point of 169°C and the mixed melting point with **5** prepared in the same way using CH_3I was not depressed; the isotopic composition of **2** was: d_3, 99.5%; d_2, 0.5%.

Mass spectra were determined on a VG Micromass 7070F instrument under the following conditions: ionizing energy, 70 and 10 eV; accelerating voltage, 4 kV; filament current, 200 μA; source temperature, 200°C; direct inlet probe; indicated source pressure, 2×10^{-6} mbar.

CONCLUSION

The evidence presented leads to the conclusion that H/D exchange between carboxyl and methylthio is slower than between carboxyl and methoxyl.

Acknowledgement

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