**Tetrahedron Letters No.36, pp. 4335-4339, 1966. Pergamon Press Ltd.
Printed in Great Britain.**

THE MECHANISM OF ELECTRON IMPACT-INDUCED ELIMINATION OF METHANOL FROM LONG CHAIN METHYL ESTERS

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(Received 29 June 1966)

The elimination of methanol is a ubiquitous process in the mass spectra of long chain hydroxy (1), alkoxy (1), branched (2, 3) and keto (1) acid methyl esters, which generally occurs from fragment ions formed by cleavage alpha to one of the above functional groups. Although long chain esters represent one of the earliest and most extensively studied classes of natural products in mass spectrometry (4), the mechanism or mechanisms of elimination of methanol from various long chain esters and the extent to which they are similar or different, is not known. This rearrangement has been assumed to be in virtually every case a 1, 2 elimination, resulting in ketene type ions (1-4), although Ryhage and Stenhagen have more recently expressed doubt that this is so in the case of the branched chain esters (5).

We have therefore undertaken a systematic investigation of this process through the use of suitable deuterium-labeled derivatives of

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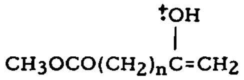
a number of long chain esters containing various functional groups in the chain. We wish to report here preliminary results obtained from keto esters, including evidence of a highly specific double rearrangement of a single hydrogen.

Keto esters were chosen for initial studies because of the attractive possibility of comparing the elimination process from two different ions (1) derived from the same molecule: that produced by simple alpha cleavage on the hydrocarbon side of the carbonyl group (a, below), and (b) the product of a McLafferty rearrangement involving a gamma hydrogen on the hydrocarbon side of the carbonyl group.

$CH_3OCO(CH_2)_n\overset{\cdot +}{C}{=}O$

a



$CH_3OCO(CH_2)_n\overset{\overset{+}{O}H}{\overset{|}{C}}{=}CH_2$

b

The mass spectrum of methyl 6-ketopentadecanoate (I) (Fig. 1) serves as a typical representative of this class of compounds, in which the

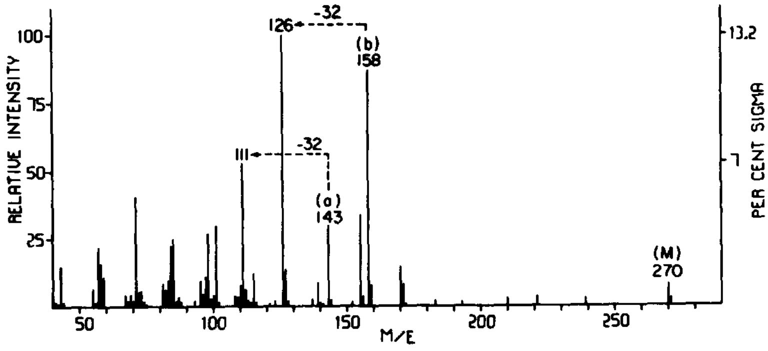


FIG. 1

Mass Spectrum of methyl 6-Ketopentadecanoate ions involved in elimination of methanol (m/e 143 (a) → 111, $m^* = 86.2$ calc., 86.2 fd., m/e 158 (b) → 126, $m^* = 100.5$ calc., 100.5 fd.) account for more than one-third of the total ion current. General interpretation of the principal peaks in the spectrum follows that previously presented for methyl 6-ketooctadecanoate and related positional isomers (1).

Results of systematic deuterium labeling experiments involving the 2-d_2, 3-d_2, 4-d_2, 5,7-d_4 and 9-d_2 analogs of I are shown in Table I (6).

TABLE I

Ion	Position of Deuterium Label					
	2	3	4	5	7	9
a	56	0	0	59	-	-
b	0	0	0	23		80

Source of Hydrogen for the Elimination of Methanol from Ions a and b as Indicated by Deuterium Labeling of Methyl 6-Ketopentadecanoate (I).

Elimination of CH_3OH from ion a occurs through two processes. Spectra of 2-d_2-I and 5,7-d_4-I indicate that approximately half of the cases are 1,2 eliminations, as postulated by the Swedish authors (1). The remaining processes involve abstraction of hydrogen (or deuterium) from C-5. The mass spectrum of methyl 7,9-d_4-8-ketoheptadecanoate reveals an analogous loss of deuterium from position 7, which demonstrates that the process is structurally specific for hydrogen alpha to the carbonyl group rather than for hydrogen bound to C-5 *per se*. The operation of an unusual isotope effect which discriminates against hydrogen (7) is apparent in the a - 32 processes, in which the sum of deuterium involvement is approximately 115% (Table I).

The elimination of CH_3OH from ion b, as shown by the mass spectra of I labeled in positions 2 through 7 (Table I), accounted for only 23% of the deuterium (from C-5, 7). This rather surprising result necessitated the conclusion that the primary process involves abstraction of hydrogen previously rearranged to the carbonyl group by McLafferty rearrangement from C-9. This conclusion was confirmed by the mass spectrum of 9-d_2-I, which shows the transfer of one deuterium from C-9 to the carbonyl group in the formation of ion b, followed by its loss to the extent of 80% during subsequent elimination of methanol.

From the data available, both the a - CH_3OH (involving hydrogen alpha to the keto group) and b - CH_3OH processes appear to be additional examples (8) of CH_3OH elimination in which a structurally unique hydrogen is abstracted to a high degree of specificity, even though its proximity to the methoxyl group through the chain may vary.

Acknowledgments. Support for this work was provided by the National Institutes of Health (HE-05435) and the Robert A. Welch Foundation (Q-125).

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2. R. Ryhage and E. Stenhagen, ibid., 15, 291 (1960).
3. R. Ryhage and E. Stenhagen, ibid., 15, 333 (1960).
4. For a summary of work in this field, see R. Ryhage and E. Stenhagen in Mass Spectrometry of Organic Ions, F. W. McLafferty, Ed., Chapter 9, Academic Press, New York (1963).
5. R. Ryhage and E. Stenhagen, Ref. 4, p. 412 (footnote).

6. Data for Fig. 1 and Table I were obtained with an Atlas CH-4 mass spectrometer with a gas chromatographic inlet system; ion source 250°, electron energy 20 ev, ionizing current 60 μa, accelerating voltage 3 KV.

7. Several cases of inverse isotope effects have been observed in the mass spectra of deuterium-labeled steroidal amides: Z. Pelah, M. A. Kielczewski, J. M. Wilson, M. Ohashi, H. Budzikiewicz and C. Djerassi, J. Amer. Chem. Soc., **85**, 2470 (1963).

8. A rearrangement of this type has been previously reported in the mass spectra of O-isopropylidene derivatives of unsaturated esters: J. A. McCloskey and M. J. McClelland, J. Amer. Chem. Soc., **87**, 5090 (1965).