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THE MASS SPECTRA OF SUPRASTEROL$_3$-II, VITAMIN D$_3$ AND RELATED MOLECULES[1]

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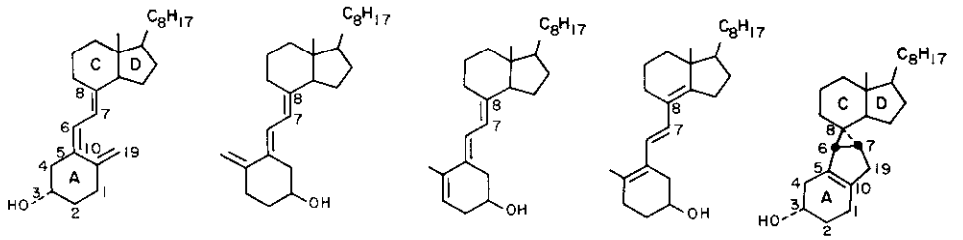
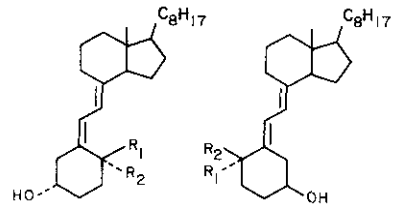
The mass spectra of vitamin D$_3$ (1)[2] and 5,6-trans-vitamin D$_3$ (2)[3] are almost identical and are uniquely characterized by the appearance of a base peak at m/e 136 with the second most intense ion appearing at m/e 118 (base peak minus water). It is of some mechanistic concern that the m/e 136 peak ($C_9H_{12}O^{+\cdot}$) for both substances is due to the A-ring plus HC-7, HC-6 and H_2C-19, which would formally require the energetically unfavorable electron impact induced cleavage across the C-7/C-8 carbon-carbon double bond.[4] Neither isovitamin D$_3$ (3)[5] nor isotachysterol$_3$ (4),[5] double bond shifted structural isomers of 1, exhibit similar mass spectral fragmentation patterns particularly in regard to significant peaks at m/e 136 and 118. In point of fact the observation of these peaks, usually as the two most intense ions, appears to be general for metabolites and analogs of 1 and 2 possessing the same stereostructural triene arrangement.[2,3,5a,6]



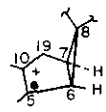
1 2 3 4 5

Investigations of fragmentation reactions occurring in the mass spectrometer have revealed processes analogous to those observed both in thermal and in photochemical reactions.[7] Studies have been reported from a theoretical[8] and experimental[4,7,9] viewpoint concerning whether ground or electronically excited states are involved in reactions induced by electron impact. It is known that 1 and 2 are not interconverted by heat,[10] but that 2 reverts to 1 upon UV irradiation.[11] It is also known that upon irradiation of 1, the major photoproduct (62%) is the bicyclo[3.1.0]hexene suprasterol$_3$-II (5).[11b,12] Because of the sometimes ob-

served parallel between photochemical and electron impact induced pathways,[13] it seemed attractive to investigate the mass spectral behavior of vitamin D_3 related valence isomers. We report herein a comparison of the mass spectrum of 5 with that of 1, and we also describe briefly the mass spectra of the four possible 10, 19-dihydro reduction products (6 - 9)[14] of 1 and 2 for further comparison.



6, R_1=CH_3; R_2=H
7, R_1=H; R_2=CH_3
8, R_1=CH_3; R_2=H
9, R_1=H; R_2=CH_3



10

11

12
$C_9H_{12}O^{+\cdot}$
(m/e 136)

The mass spectra (70 eV) of 1 and 5 are given in Figures 1A and 1B respectively. The spectra of 1, 5, and 2 (not shown)[15] are dominated by the m/e 136 (base) and 118 (78%, 79% and 76%, respectively) peaks and all three spectra exhibit metastables at m/e 48.2 and 102.4 attributable to the processes m/e 384 → 136 and 136 → 118, respectively. Slow scans at 70 and 20 eV showed that for the three compounds the broad metastable peaks at m/e 48.2 are virtually superimposable, and the same was observed for the narrow metastable peaks at m/e 102.4.[16a] Moreover, the spectra of 1 and 2 are nearly identical. Below m/e 140, the spectra of 1 and 5 are also almost identical; although at higher masses peaks due to 5 are less intense than those for 1, similarities are apparent at a tenfold expanded intensity scale (Figure 1B). Fragments at m/e 271 and 253, characteristic of the loss of the side chain and 271-H_2O, respectively, previously mentioned for 1[2] and 2,[3] are also observed for 5. Abundance ratios for 1 and 5 of competitive metastable ion fragmentations in the first field-free region (so called HV scans[16a,b]) at 70 and 20 eV indicate that although some fragments arise from different precursors, those at m/e 369, 271, 259, 253, 211 (and 136, from the metastable peak shapes) appear to be generated from precursors having a common structure.

In view of the near-identity of the spectra observed for 1 and 2,[3,15] we also examined the spectra of 6 - 9 which differ from one another only in their C-10 and/or their Δ^5 configurations.[17] The four stereoisomers exhibit qualitative similarities:[18] m/e 386 (parent), 302, 301, 273, 259, 255, 247 and groups of peaks at 121,119/ 107,105/ 95,93,91/ 81,79/ 71,69,67/ 57,55/ and 43. The distribution of intensities differs widely, however. Most significantly, a peak resulting from C-7/C-8 cleavage (m/e 138) is absent (<0.5%) for all four compounds. These observations complement the earlier results in which neither 3 nor 4 exhibited significant C-7/C-8 scission fragments upon electron impact.[5]

As regards a possible mechanistic pathway through which 5 traverses to give the m/e 136 species (presumably 12), obvious choices for intermediates include

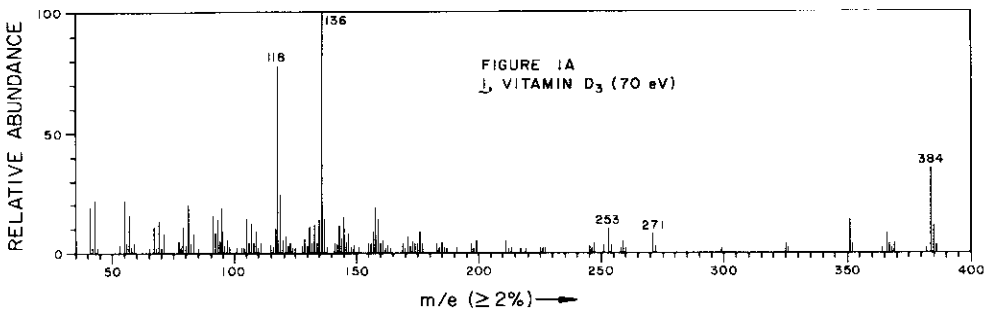


FIGURE 1A
1, VITAMIN D_3 (70 eV)

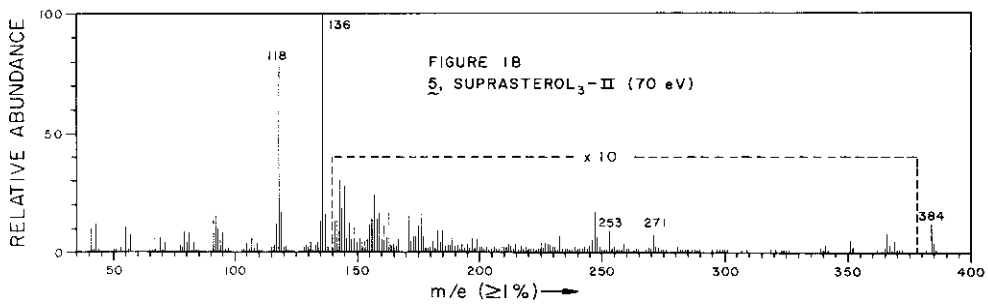


FIGURE 1B
5, SUPRASTEROL$_3$-II (70 eV)

10 and 11. The mass spectral results described above indicate that the major decomposition path of the molecular ions of 1, 2 and 5 proceeds via a common intermediate structure or set of structures (possibly 10 and/or 11) to the same m/e 136 species (12). Since the three isomers are photochemically but not thermally interconnected, this finding suggests a parallel between the mass spectrometric and photolytic reaction paths.[19] The intermediacy of structures like 10 and/or 11 nicely accounts for the formal cleavage across the C-7/C-8 bond in 1 and 2, while no such scission occurs in compounds 3, 4 and 6-9.

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15. A side by side comparison of the mass spectra for 1, 2 and 5 were made at 15, 20 and 70 eV. The mass spectral data were obtained with an AEI MS-902 mass spectrometer, using a direct insertion probe at temperatures of 50-60°C above ambient (to avoid thermal reactions[10]). In utilizing metastable ion decompositions as evidence for ion structure identity, there are possible pitfalls. For example, see K. Levsen and F. W. McLafferty, J. Am. Chem. Soc., 96, 139 (1974).

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17. The spectrum of 8 has been previously published. See T. Suda, R. B. Hallick, H. F. DeLuca and H. K. Schnoes, Biochem., 9, 1654 (1970).

18. These spectra were recorded at 70 eV on a Finnigan 1051C Mass Spectrometer.

19. However, this does not imply that cycloaddition of $1^{+\cdot}$ (or $2^{+\cdot}$ via $1^{+\cdot}$) to a suprasterol-like structure (e.g., 10) necessarily precedes further fragmentation. Other pathways, e.g., cyclization to structure 11 directly, seem equally well feasible.