

AFAIRL-TR-84-060

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SEP 17 1984

AD-A145 629

A Facile Method of Detecting the Metabolites of the Jet Fuel JP-10

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Abstract

The 70 eV and 20 eV electron impact (EI) and 70 eV chemical ionization (CI) mass spectra for the trimethylsilyl (TMS) derivatives of alcoholic metabolites of exo-octahydro-4, 7-methano-1H-indene (JP-10) are reported. Fragmentation patterns of the TMS derivatives can be used as an analytical tool to identify the position of hydroxyl group in JP-10 metabolites.

Introduction

JP-10 is a newly synthesized high density fuel used in the Air Force's air-launched cruise missile. JP-10 is the exo-isomer of 2,3,3a,4,5,6,7,7a-octahydro-4,7-methano-1H-indene (I). Toxicity data on JP-10 indicated that the acute oral LD₅₀ was greater than 20 ml/kg and an inhalation LC₅₀ for the rat was about 1200 ppm (1). This new generation fuel may on occasion be involved in accidental environmental contamination as well as low concentration occupational exposure. Rat urine studies have shown that monohydroxylation (2) is the major metabolic pathway by which JP-10 is metabolized. A simple method to identify the absolute stereochemical position of the OH on I would be a valuable tool in evaluating the toxicity problems that might arise from the use of JP-10, as well as in providing a future simple non-invasive technique for measuring human exposure to I. Various monohydroxy derivatives of I were synthesized and their trimethylsilyl (TMS) derivatives (Table I) prepared. The fragmentation patterns of the TMS derivatives obtained by electron impact (EI) and chemical ionization (CI) positive mode mass spectrometry were studied.

Experimental

Materials

Alcohols, 1-exo-hydroxy JP-10, 1-endo-hydroxy JP-10, 2-exo-hydroxy JP-10, 2-endo-hydroxy JP-10, 5-exo-hydroxy JP-10,

5-endo-hydroxy JP-10, and 8-anti-hydroxy JP-10, were prepared according to the literature(3-7). Tri-Sil Z reagent (trimethylsilylimidazole in dry pyridine) was purchased (Pierce Chemical) and used as received.

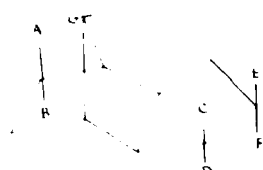
Method

The individual alcohol (1 to 1.7 mg) was placed in a 1-ml reacti-vial and 100 μ l of TMS reagent was added. After allowing 30 min at room temperature for the formation of the TMS derivatives, 0.5 to 1 μ l of the reaction mixture was subjected to EI mass spectrometry at 70 eV and 20 eV and to CI mass spectrometry at 70 eV at a temperature of 200°C.

Instrumentation

All spectra were obtained on a model 5985 quadrupole mass spectrometer (Hewlett-Packard) equipped with a 6-ft $\times$ 1/4-in o.d. glass column packed with 10% SE-30 on 80/100 mesh Chromosorb W-HP. Helium was used as the carrier gas (25 ml/min) and methane as the reactant gas for the CI mode (25 ml/min). The injection port was maintained at 180°C. The column temperature was programmed from an initial oven temperature of 130°C held for 1 min, with a program rate of

Table I. TMS Derivatives of Monohydroxy JP-10



Compound	A	B	C	D	E	F	G	Retention time (min)
I	H	H	H	H	H	H	H	—
II	OTMS	H	H	H	H	H	H	9.90
III	H	OTMS	H	H	H	H	H	9.27
IV	H	H	OTMS	H	H	H	H	10.15
V	H	H	H	OTMS	H	H	H	9.68
VI	H	H	H	H	OTMS	H	H	10.47
VII	H	H	H	H	H	OTMS	H	9.70
VIII	H	H	H	H	H	H	OTMS	8.80

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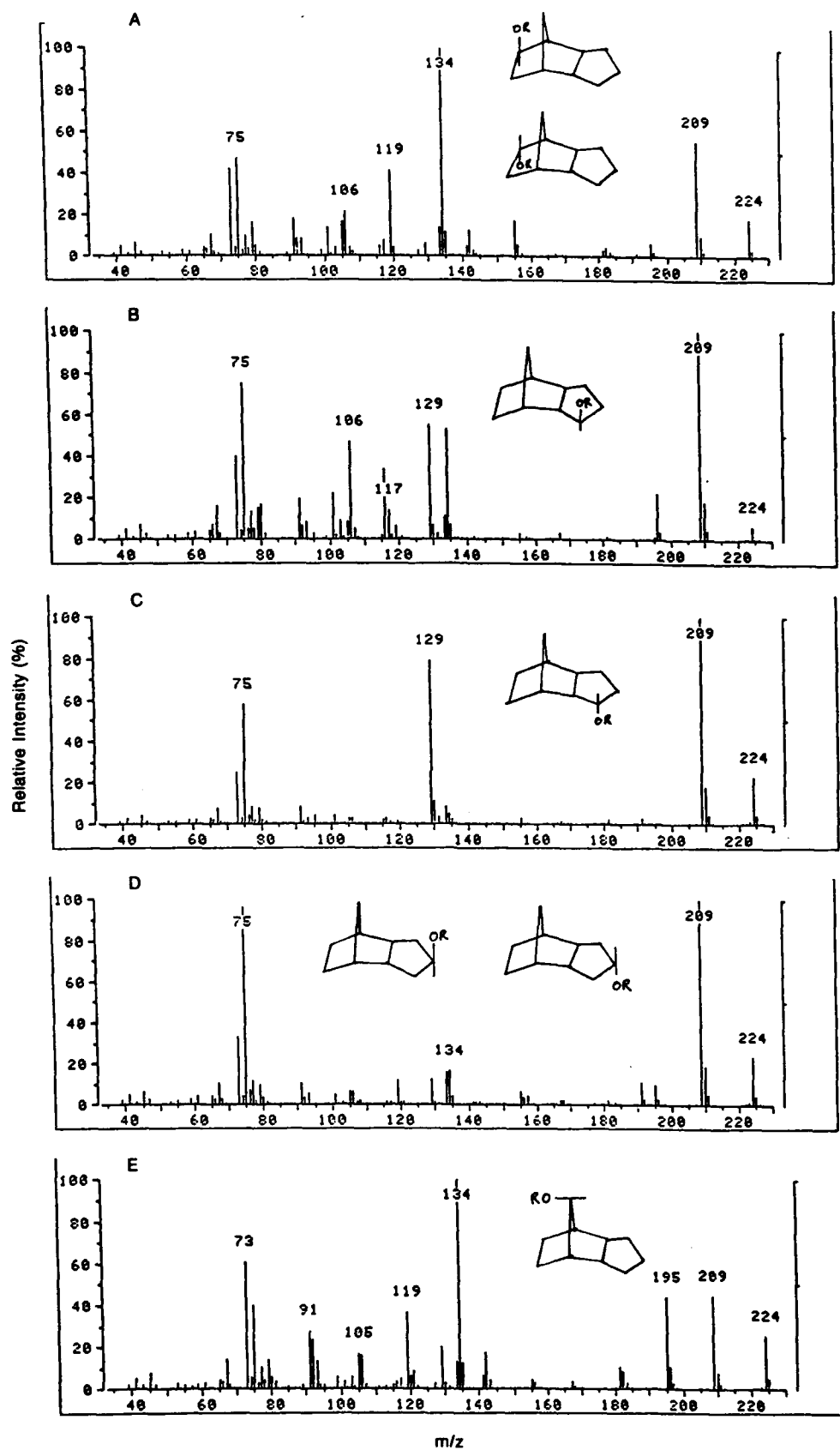


Figure 1. 70 eV EI mass spectra of TMS derivatives II to VIII of monohydroxy JP-10: (A) II, III; (B) IV; (C) V; (D) VI, VII; (E) VIII. R = -TMS.

Table II. Principal Fragmentations and Their Relative Abundances in the 70 eV EI Mass Spectra of TMS Derivatives of Monohydroxy JP-10

m/z	Compound						
	II	III	IV	V	VI	VII	VIII
224	18	16	6	23	24	21	26
209	56	48	100	100	100	100	45
196	3	2	22	1	3	2	11
195	7	6	2	1	10	9	44
155	18	16	3	3	7	5	5
142	13	12	2	1	2	2	18
134	100	100	53	5	17	16	100
129	6	7	55	79	12	11	—
119	42	42	7	2	12	11	37
116	5	6	34	3	2	2	4
106	22	24	47	3	7	6	16
105	17	18	9	3	6	6	17
101	14	15	22	4	5	4	4
91	18	21	22	9	11	11	28
75	47	46	75	58	96	91	40
73	42	47	40	25	34	28	61

5°C/min, to the final temperature of 200°C held for 5 min. Results of the GC/MS study of the TMS derivatives are given in Tables II to IV. No alcohols were detected in any of the experiments undertaken.

Results and Discussion

The 70 eV mass spectra of compounds II to VIII are listed in Table II and shown in Figure 1. With the exception of compound IV, all the rest of the TMS alcohol derivatives showed a discernible molecular ion peak at m/z 224. Compounds IV, V, VI, and VII showed the ion m/z 209 (M-15), characteristic of TMS ether $[M-CH_3]^+$, as the base peak. The ion m/z 134 (M-90) corresponding to $[M-(CH_3)_2SiOH]^+$ occurred as the base peak for compounds II, III, and IV. The ion m/z 129 (M-95) was significant for compounds IV and V. The compounds II, III, and VIII produced the ion m/z 119 (M-105) in abundance. Compound IV was the only compound to give appreciable amounts of ions m/z 116 (M-108) and 106 (M-118). Ions m/z 75 (M-149) and 73 (M-151) were formed by all the compounds in various abundances.

Regarding the 70 eV mass spectra fragmentation patterns for compounds II to VIII, compounds II, III, and VIII can be separated from the other TMS isomers using ions m/z 209, 134, and 119. Compound VIII can be solely identified using ions m/z 195 and 73. Compounds IV, V, VI, and VII can be separated from the other isomers by the ion m/z 209. Compound IV can be clearly identified using the ions m/z 196, 134, 116, 106, and 101. Compound V has the ion m/z 129, which is uniquely abundant for that isomer. Compounds VI and VII possess a large abundance of ion m/z 75, which can be used as an identification marker.

Because of the difficulty in separating the stereoisomer pairs II, III and VI, VII from each other, it was decided to examine these isomers using 20 eV EI and CI mass spectrum. The results shown in Tables III and IV, respectively, indicate that the mass

Table III. Principal Fragmentation and Their Relative Abundances in the 20 eV EI Mass Spectra of TMS Derivatives of Monohydroxy JP-10

m/z	Compound						
	II	III	IV	V	VI	VII	VIII
224	16	15	6	61	45	48	18
209	14	14	53	100	100	100	9
134	100	100	100	8	22	26	100
129	—	—	9	57	—	—	—

Table IV. Principal Fragmentations and Their Relative Abundances in CI Mass Spectra

m/z	Compound						
	II	III	IV	V	VI	VII	VIII
225	13	14	15	16	9	14	35
224	7	8	13	13	10	12	13
223	19	25	33	37	34	36	36
209	66	78	100	100	100	100	100
135	100	100	69	54	62	56	56

spectra are not useful in discerning II from III or VI from VII.

In conclusion, the TMS derivatives of the various monohydroxy isomers of I do permit the unequivocal identification of carbon to which the OH group is attached. However, the exact stereochemical positioning of the OH is not discernible using this technique.

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Manuscript received September 2, 1983;
revision received January 12, 1983.



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