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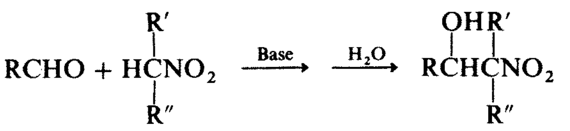
New Mass Spectra

Negative Ion Mass Spectra of β-Nitroalcohols

β-Nitroalcohols are interesting intermediates in organic synthesis owing to the versatility of both the nitro and the alcohol groups, which can be converted into a number of derivatives, among which the *β*-aminoalcohols constitute a very important class of biologically active compounds.[1–4] *β*-Nitroalcohols are readily synthesized by base-promoted condensation of nitroalkanes with aldehydes (Henry reaction),[5] according to the equation



$$\mathrm{RCHO} + \mathrm{H}\overset{\mathrm{R'}}{\underset{\mathrm{R''}}{\mathrm{C}}}\mathrm{NO_2} \xrightarrow{\text{Base}} \xrightarrow{\mathrm{H_2O}} \mathrm{R}\overset{\mathrm{OH}}{\mathrm{C}}\mathrm{H}\overset{\mathrm{R'}}{\underset{\mathrm{R''}}{\mathrm{C}}}\mathrm{NO_2}$$

1

We prepared a series of *β*-nitroalcohols covering a number of possible substitution patterns for the general structure **1** (see Table 1). In particular, the *β*-nitroalcohols **1a–f** were prepared by mixing equimolar amounts of the appropriate nitroalkane, aldehyde and 1,1,3,3-tetramethylguanidine in tetrahydrofuran (giving *ca.* 1 M of each reagent) and stirring at 20 °C for 20 h. After quenching with cold 0.5 M hydrochloric acid, the product was extracted with diethyl ether and purified by silica gel flash chromatography using cyclohexane–ethyl acetate (9 : 1, v/v) as eluent. The *β*-nitroalcohols **1g–k** were obtained using a similar procedure but replacing the guanidine with triethylamine and tetrahydrofuran with dichloromethane.

Positive-ion electron-impact mass spectrometry is not useful for this class of compounds. In fact, for simple nitroalkanes, with the exception of nitromethane,[6,7] and particularly when R in **1** is an aliphatic chain, molecular ions are not detected. The typical decomposition of the molecular ion involves the loss of NO_2 or HONO and the resulting *β*-hydroxycarbonium ions $[M - 46]^+$ and enol ions $[M - 47]^{+\cdot}$ exhibit extensive fragmentation.

In this paper we report a useful application of negative-ion mass spectrometry in the analysis of a series of *β*-nitroalcohols.

All spectra were obtained using a VG 7070 instrument with the following operating conditions: ionizing energy, 70 eV; emission current, 1.1 mA; accelerating voltage, 6 kV; source temperature, 180 °C; and resolving power, 1000. The *β*-nitroalcohols were introduced via the heated septum inlet (180 °C). When the septum inlet valve is opened, the source pressure is about 1×10^{-6} mbar (1 mbar = 100 Pa) and under these conditions no negative ions are visible on the monitor screen. The source pressure is gradually increased with air up to 1×10^{-5}–1.6×10^{-5} mbar as indicated on the control panel meter. At this pressure, the thermalization of the 70 eV electrons by collision with neutral molecules and the collisional stabilization of the negative ions formed allow a good level of total negative-ion current to be achieved; intense negative ions were observed, and spectra were recorded by repetitive scanning over the range 20–500 u using a 30 s scan.

The negative-ion mass spectra are given in Table 1. The most important fragmentation involves the cleavage of the C—N bond leaving the NO_2^- ion (*m/z* 46) as the base peak in all the substrates examined, except **1k**.[8] Molecular ions $[M]^{-\cdot}$ are generally observed (their abundances range from 2 to 34%). This feature makes the reported technique a reliable source of information about the molecular mass. Another common feature to several *β*-nitroalcohols is the presence of nitronate ions $[R'R''C{=}NO_2]^-$ at *m/z* 60, 74 or 88. When R is an aliphatic group, an adduct ion $[M + 46]^-$ is always observed. Accurate mass measurements (10 000 resolving power, peak matching mode using perfluorokerosene as reference standard) of the *m/z* 207 ion in the spectrum of **1a** established the molecular formula $C_7H_{15}N_2O_5$ (found, 207.09777; required, 207.09810), suggesting the formal incorporation of NO_2 into the molecular ion by an ion–molecule reaction, for example between a molecular ion and a neutral *β*-nitroalcohol molecule. This has not previously been observed, to our knowledge, in the electron-impact or chemical-ionization negative-ion mass spectra of aliphatic nitro derivatives. The formation of an ion adduct of formula $[M + 46]^-$ has been proposed by Ballantine *et al.*[9] to explain the production of $[M + 13]^-$ ions in the negative-ion chemical-ionization mass spectra of a series of simple nitroalkanes.

We wish to stress the advantage of this negative-ion technique in the case of substrate **1g**. The positive-ion mass spectra of trialkylsilyl ethers generally show very small molecular ions and intense $[M - 15]^+$ peaks and ions coming from α-cleavages with respect to silicon. In contrast, the presence of a *tert*-butyl dimethylsilyl ether group in the *β*-nitroalcohol does not interfere with the general behaviour of this class of molecules, and again the only noticeable ions are NO_2^-, $[M]^{-\cdot}$ and $[M + 46]^-$.

The adduct $[M + 46]^-$ was not observed in the spectra of **1h–k**. In fact, when R is an aromatic ring we observe the molecular ion $[M]^{-\cdot}$, a dehydrated ion $[M - 18]^{-\cdot}$ corresponding to a *β*-aryl nitroalkene and $[M - 48]^-$ ions corresponding to the enolate of an arylacetaldehyde. Since we did not find metastable ions corresponding to the loss of water from the molecular ions, dehydration is probably a thermal reaction of these thermally labile compounds. The $[M - 18]^{-\cdot}$ ions give rise to the $[M - 48]^-$ ions and this fragmentation is the sole analogy between the positive- and negative-ion mass spectral behaviour of nitro derivatives recorded in this work. In fact, aromatic nitro compounds and *β*-arylnitroalkenes under both positive and negative electron-impact conditions,[7,10,11] and also on photoexcitation,[12] undergo a rearrangement to the isomeric nitrite esters followed by extrusion of NO. A partial exception is given by the 4-biphenyl-substituted *β*-nitroalcohol **1k**. In this case NO_2^- is not the base peak, the molecular ion is absent, and only three other ions are detected, namely $[M - 18]^{-\cdot}$, $[M - 48]^-$ and the ion at *m/z* 182 corresponding to 4-biphenylcarboxaldehyde. The last ion comes from a McLafferty-type rearrangement involving transfer of the hydroxylic hydrogen to the nitro group followed by elimination of neutral nitronic acid.

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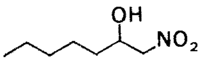
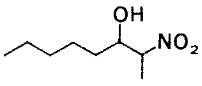
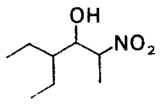
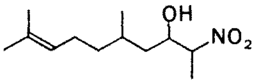
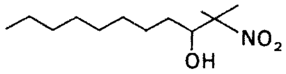
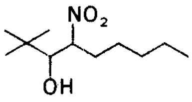
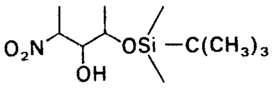
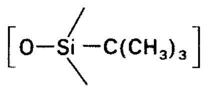
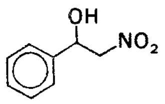
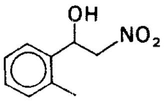
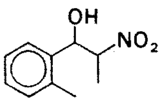
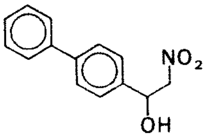
Table 1. Negative-ion mass spectra of typical β-nitroalcohols

Substrate	$[M]^{-\cdot}$ m/z (RI)[a]	Relative intensity of peaks (%)[b]			Others m/z (RI)[a]
		$[M+46]^-$	$[M-18]^{-\cdot}$	$[M-48]^-$	
 **1a**	161 (28)	5	0.5	—	60 (1)
 **1b**	175 (34)	21	—	—	74 (tr.)
 **1c**	175 (18)	5	—	—	74 (0.5)
 **1d**	229 (4)	3	3	—	74 (tr.)
 **1e**	231 (4)	2	—	—	88 (2)
 **1f**	217 (9)	5	—	—	—
 **1g**	263 (22)	12	—	—	131 (3) 
 **1h**	167 (4)	—	30	54	60 (5)
 **1i**	181 (2)	—	4	65	60 (2) 180 (3) 134 (5)
 **1j**	195 (2)	—	3	8	—
 **1k**[c]	243 (0)	—	100	56	182 (8)

[a] RI = relative intensity (%) in parentheses; tr. = trace.

[b] The relative intensity refer to the peak at m/z 46, which is the base peak in all cases except **1k**.

[c] The relative intensity of the peak at m/z 46 is 15%.

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