NOTE TO THE EDITOR

Deuterium-induced ^{13}C Nuclear Magnetic Resonance Isotope Shifts and $^{13}C—^{2}H$ Couplings for Signal Assignments and Determination of Deuteration Site in Cyclooctanone

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Unambiguous signal assignments in the ^{13}C spectra of monodeuterated cyclooctanones derived from the lead tetraacetate or silver oxide/bromine oxidations of the corresponding 1-monodeutero-alcohols have been obtained from deuterium-induced ^{13}C isotope shifts and geminal and vicinal $^{13}C—^{2}H$ spin–spin coupling constants. The label in the ketones is shown to be in position 5.

INTRODUCTION

The present study was undertaken with the objective of determining the deuterium labelling site(s) in cyclooctanone formed upon oxidation of [1-$^{2}H_1$]cyclooctanol with lead tetraacetate (LTA)[1] or silver oxide/bromine (Ag_2O/Br_2).[2] The LTA reaction was carried out in benzene under thermal (80 °C) and photolytic (20 °C, UV irradiation) conditions. Mass spectra of the cyclooctanones, isolated from the reaction mixtures using preparative GLC, revealed a high percentage of monodeuterated species (i.e. 22%, 65% and 86% in Ag_2O/Br_2, LTA-thermal and LTA-photolytic reactions, respectively) and at the same time excluded carbons 2 and 3 as those bearing a deuteron (based on the complete retention of the label in all cases in the $M—C_2H_4$ ion).[3] However, it could not be deduced with certainty whether a deuteron was attached to C-4 and/or C-5. ^{13}C NMR spectroscopy lends itself as the method of choice, since the chemical shifts are susceptible to deuterium labelling.[4]

The proton-noise decoupled ^{13}C NMR spectrum of the pure protio isotopomer [Fig. 1(a)], permits designation of the signals of C-1, C-2 and C-5 on the basis of their unique chemical shifts and relative intensities. The distinction between C-3 and C-4, however, remained ambiguous at this stage. Further information was obtained from the spectra of the monodeutero species [Fig. 1(b)]. As far as deuterium induced shifts and $^{13}C—^{2}H$ couplings are concerned, both LTA and Ag_2O/Br_2 ketones exhibited identical spectra, indicating the same site of deuteration. The spectrum of the mixture of deutero and protio isotopomers affords, in addition to a single line at δ_C 24.797, a 1:1:1 triplet at δ_C 24.405. The isotope effect $\Delta\delta_C$, −0.392, and the coupling [^{1}J(CD) 19.1 Hz] are typical of a directly bonded deuteron.[4] This shows that deuteration has taken place at C-5. Moreover, the original line at δ_C 27.248 is split into a narrow low field component (δ_C 27.239) and a broader high field line at δ_C 27.139. The upfield shift $\Delta\delta_C$, −0.100, characteristic of a geminal isotope shift, and the broadening of the higher field line due to non-resolved geminal $^{13}C—^{2}H$ coupling, enabled assignment of this signal to C-4. Since the two lines are well separated, and originate from two carbons which are expected to have the same NOE, they are well suited for corroborating the deuteration ratio from integration (see expansion, Fig. 1(b)). The integral afforded almost identical values to those obtained from mass spectrometry. The part of the remaining signal (assignable to C-3), which is shifted by an amount $\Delta\delta_C = -0.033$ (vicinal isotope effect)[4] from the original position (δ_C 25.710), shows resolved splitting due to three-bond $^{13}C—^{2}H$ coupling [^{3}J(CD) 0.75 Hz].

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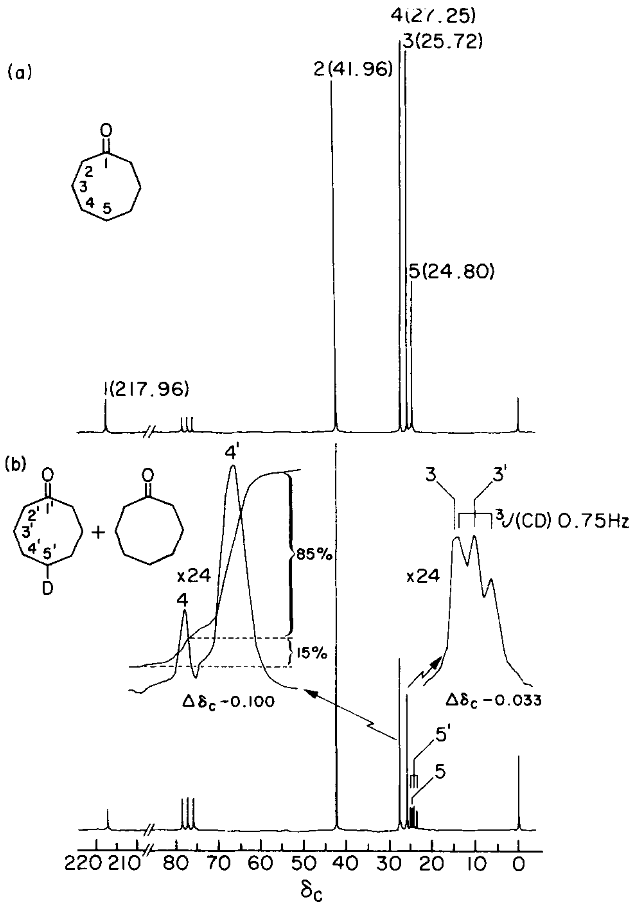

Figure 1. 25.2 MHz proton noise-decoupled ^{13}C NMR spectra; (a) cyclooctanone; (b) ketonic product from the LTA photolytic reaction of 1-deuterocyclooctanol.

From the above data it can be inferred that both LTA and Ag_2O/Br_2 oxidations of cyclooctanol involve a 1,5-hydrogen shift from C-1 to C-5.

EXPERIMENTAL

The starting [1-$^2H_1$]cyclooctanol was prepared by $LiAlD_4$ reduction of cyclooctanone.

The lead tetraacetate and silver oxide/bromine oxidations of [1-$^2H_1$]cyclooctanol were carried out according to general procedures described previously.[1,2] The ketonic products were isolated using preparative GLC (Varian Aerograph Model 920, TCD, 10% Carbowax 20 M on Chromosorb W, 60/80 mesh, length 2 m, i.d. 0.6 cm, 125 °C, H_2).

The ^{13}C NMR spectra were run in the proton noise decoupled mode at 25.2 MHz on a Varian XL-100 spectrometer using the following experimental conditions: spectral width, 6016 Hz; acquisition time, 2 s; pulse width, 10 μs; number of data points, 32 000. In order to minimize broadening effects due to residual coupling, the decoupler frequency was centred on the proton resonances and the band width reduced to *c.* 500 Hz. The samples were dissolved in $CDCl_3$ in 12 mm tubes and the chemical shifts referenced to internal TMS.

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