

APPLICATION OF ^{13}C NMR SPECTROSCOPY IN THE ASSIGNMENT OF ^1H NMR SIGNALS OF NONEQUIVALENT SCH_3 GROUPS

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The SCH_3 groups of 3- and/or 5 alkyl substituted 2,4,6-trithiaheptanes have almost identical chemical shifts in both ^1H and ^{13}C nmr spectra. A combination of gated decoupling and single-frequency off-resonance decoupling, followed by the construction of graphs of the type proposed by Pachler, allows the assignment of the ^1H nmr signals.

Les graphes SCH_3 des composés 2,4,6-trithiaheptanes substitués en position 3 et 5 par des groupes alkyls ont des déplacements chimiques presque identiques dans leurs spectres rmn au ^{13}C et ^1H . Une combinaison de découplage à fenêtre et de découplage à fréquence unique hors-résonance, suivie par la construction de graphiques de type proposé par Pachler, permet l'attribution des signaux rmn ^1H .

The ^1H and ^{13}C nuclear magnetic resonance spectra of the 2,4,6-trithiaheptanes la-e provide some examples of a familiar problem in the interpretation of nmr spectra. The problem, common to compounds with several chemically nonequivalent $-\text{OR}$, $-\text{SR}$, or $-\text{NR}_2$ groups, is the assignment of singlet resonances with very small chemical shift differences, and is illustrated here by the assignment of the nonequivalent S-CH_3 groups of Ib and Ic. In both these examples the C-1 and C-7 S-CH_3 signals are sharp singlets in both the usual fully decoupled ^{13}C spectrum and in the ^1H spectrum, with such a small range of chemical shifts observed for the series la-e that assignments based on the effect of substituents on chemical shifts must be questionable. There are many reports (Freeman and Hill 1971, Shaw 1973) on the correlation of ^{13}C spectra with ^1H spectra followed by assignment of the ^{13}C spectrum from easy assignment of the ^1H spectrum, and a few cases have been reported (Luzikov *et al.* 1975, McCabe and Nelson 1976) in which the ^1H spectrum has been assigned from correlation with an easily interpreted ^{13}C spectrum. We report an example in which neither ^1H or ^{13}C spectrum is readily assigned, yet both assignments are accessible from various combinations of decoupling experiments.

The starting point of our assignment is the observation that in the ^{13}C spectrum of Ia, measured under conditions of gated decoupling, (Feeney *et al.* 1970) the S-CH_3 signal is a quartet ($J = 139.0$ Hz) of triplets ($J = 4.7$), with the triplet splitting the result of the three-bond proton-carbon coupling through sulfenyl sulfur. In Ib and Ic the gated decoupling gives a quartet ($J = 138.9$) of triplets ($J = 4.5$) for C-7, while C-1 appears as a quartet ($J = 138.8$) of doublets ($J = 4.0$ for Ib, $J = 4.2$ for Ic). Hence, the gated decoupling experiment acts as a probe of the asymmetry of the molecule and the ^{13}C spectrum may be assigned.

Correlation of the ^1H and ^{13}C spectra was made for each compound from measurement of a series of 6-8 off-resonance decoupled spectra with a different value of the decoupling frequency for each spectrum of the series. These spectra yield values of J_{RED} , the residual directly bonded carbon-proton coupling constant, as a function of decoupling frequency. These J_{RED} measurements are then used to construct plots of the type proposed by Pachler (Pachler 1972) in which values of the ratio $J_{\text{RED}}/(J_o^2 - J_{\text{RED}}^2)^{1/2}$, where J_o is the magnitude of the directly bonded C-H

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coupling constant measured in the gated decoupling experiment, are plotted vs decoupler frequency, with the zero intercept on the x-axis giving the resonance frequency of the directly bonded proton. This method has been shown valid (Pachler 1972) for values of $\frac{\nu_{\text{Hz}}}{2\pi} \gg |1/2|J_0 - J_{\text{RED}}|$, a condition easily satisfied by the maximum decoupler power of the Varian CFT-20 spectrometer. The plots were excellent straight lines over a range of decoupling frequencies 1000 Hz on either side of the resonance frequency and the intercepts were determined by linear regression analysis. The assignments Ib and Ic agree with what might be expected, in that substitution at C-3 should affect the chemical shift of C-1 protons more than that of C-7 protons, however the real test of the method is the assignment of S-CH₃ proton signals in Id and Ie. Id and Ie were prepared as a diastereomeric mixture and all spectra recorded on solutions of mixture. The graphical method predicts the signal of the S-CH₃ protons for the major product Id and the minor product Ie. These are easily distinguished by the relative peak areas and the experimental measurement places Ie 4.8 Hz above Id. The usual plots of J_{RED} vs decoupler frequency (Birdsall *et al.* 1981), even for much narrower ranges of decoupling frequency, were much less accurate and could give misleading results in cases such as this where chemical shift differences are small.

The assignment method outlined here should be applicable to other -SCH₃, -OCH₃, or -N(CH₃)₂ examples for which an internal asymmetry of the molecule may be exploited to assign the ¹³C spectrum. It is particularly applicable to cases for which chemical shift differences are so small that low-power selective decoupling is impractical, and for which 2-D experiments would require inordinate spectrometer time in order to achieve the resolution needed.

Experimental

¹³C nmr spectra were recorded at 20 MHz and ¹H nmr spectra recorded at 80 MHz using a Varian CFT-20 spectrometer. The same solution containing 100-250 mg/ml CDCl₃ was used for both sets of spectra. The fully decoupled ¹³C spectra were recorded with a spectral width of 4000 Hz and the gated decoupling experiments were carried out with the smallest possible spectral width for which "foldover" of spectral lines could be avoided, typically 1000 Hz. The preparation and characterization of compounds Ia-e has been reported on elsewhere (Grossert *et al.* 1981).

Table I

S-CH₃ signals in the ¹H and ¹³C NMR spectra of 2,4,6-Tri-thiaheptanes CH₃ SCHRSCHR'SCH₃

Compound	R	R	$\delta_{13\text{C}}$ (C-1)	$\delta_{13\text{C}}$ (C-7)	$\delta_{1\text{H}}$ (C-1)	$\delta_{1\text{H}}$ (C-7)
Ia	H	H		14.19		2.15
Ib	Me	H	11.34	14.23	2.10	2.16
Ic	Bu ⁿ	H	12.12	14.98	2.05	2.15
Id	Me	Me		12.8		2.16
				(major diastereomer)		
Ie	Me	Me		11.3		2.10
				(minor diastereomer)		

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