C8953
NMR structural analysis seminar

Elucidenting the structure using variouse NMR techniques

Jan Novotný
176003@mail.muni.cz

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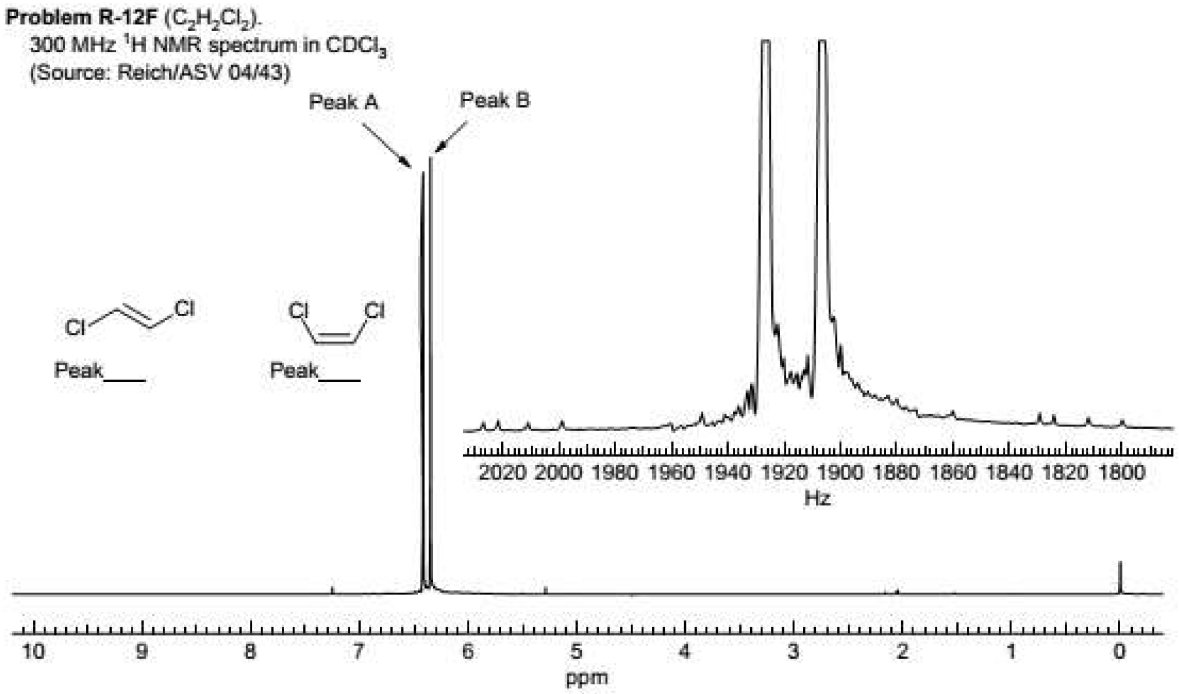
Problem R-12F. Below is the 300 MHz ^{1}H NMR spectrum of a nearly 1:1 mixture of the *E* and *Z* isomers of 1,2-dichloroethylene. Also shown is a vertical and horizontal expansion.



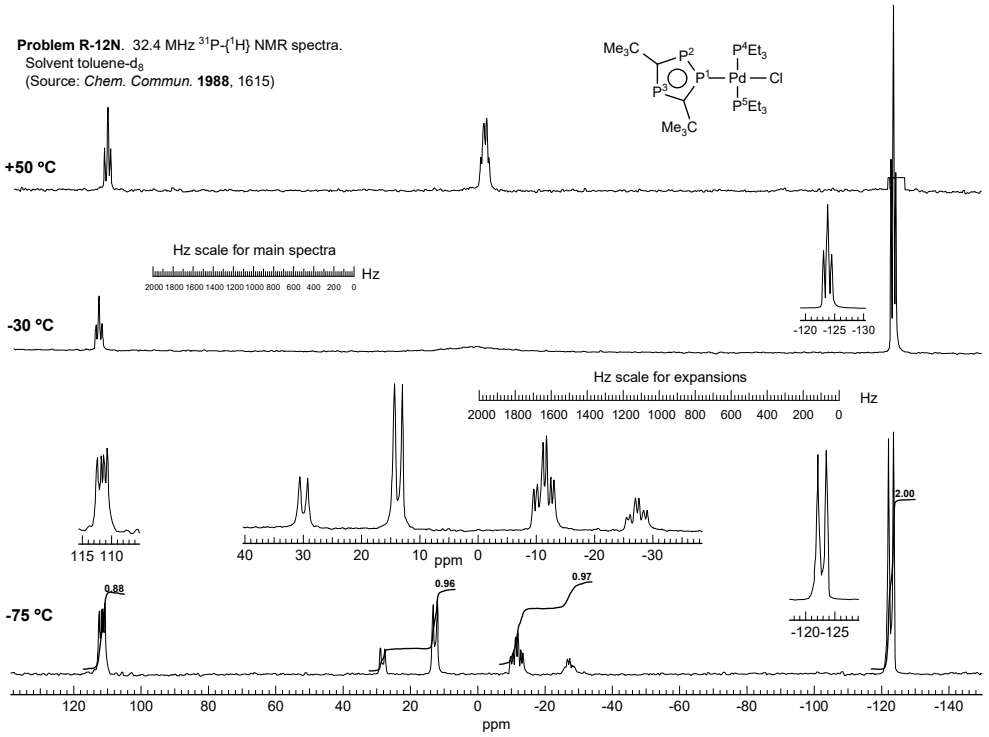
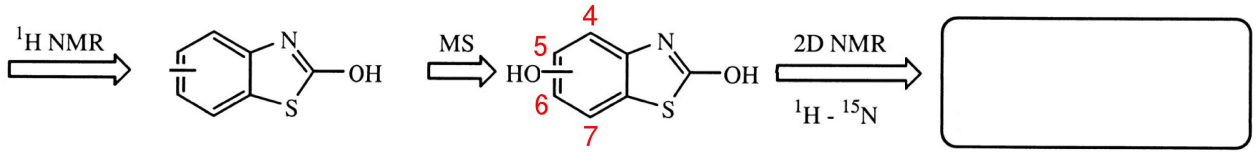

Problem R-12N. 32.4 MHz 31P-{1H} NMR spectra.
Solvent toluene-d8
(Source: Chem. Commun. 1988, 1615)
Me3C
P2
P4Et3
P1
Pd
Cl
P3
P5Et3
Me3C
+50 °C
Hz scale for main spectra
2000 1800 1600 1400 1200 1000 800 600 400 200 0
Hz
-120 -125 -130
-30 °C
Hz scale for expansions
2000 1800 1600 1400 1200 1000 800 600 400 200 0
Hz
115 110
40 30 20 10 ppm 0 -10 -20 -30
2.00
0.88
0.96
0.97
-120-125
-75 °C
120 100 80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140
ppm

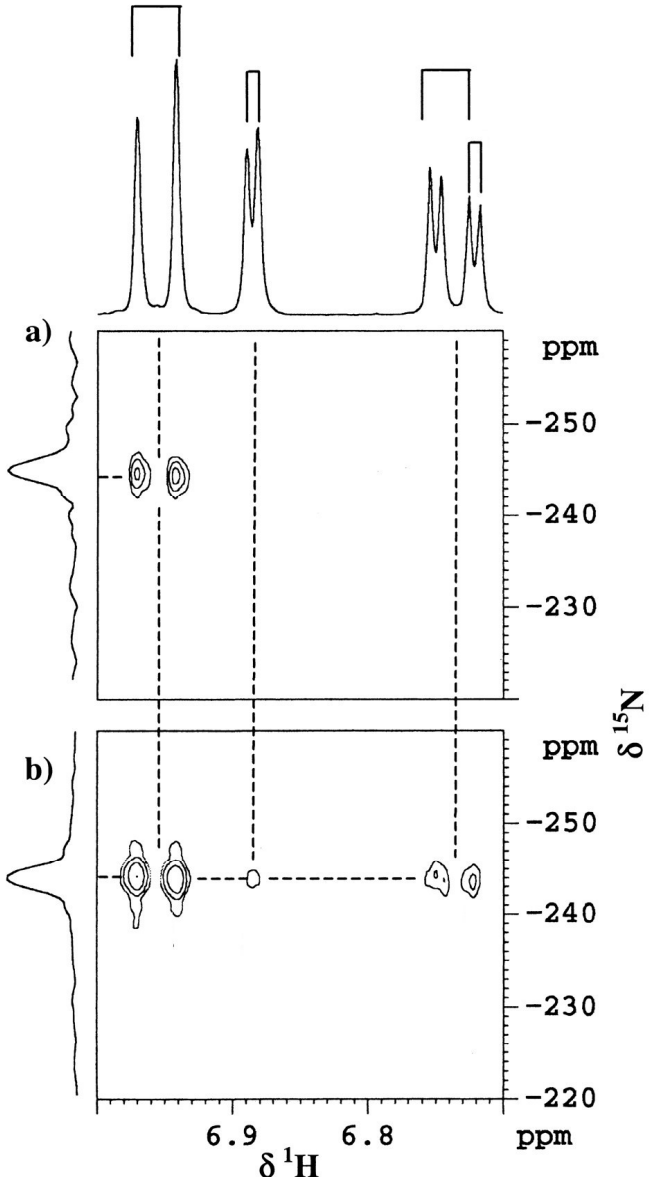
Table 1- Typical 2D NMR experiments used for molecular structure determination (*)

Experiment	Typical quantity (mg)	Exp. Time*	What kind of information is obtained?
COSY	5 mg	5 to 30 min	Establishes correlation between spins with scalar coupling (J) but does not determine coupling constants.
Long-range COSY	5 mg	5 to 30 min	Emphasize correlation with small Js.
COSY-45	5 mg	5 to 30 min	Decreases the intensity of the diagonal peaks with respect to the correlation peaks, thus identifying correlation between strongly coupled spins.
DQ-COSY	5 mg	10 to 60 min	Establishes correlation between spins with scalar coupling (J); can be used to measure Js. Singlets are removed (CH_3 signals, for example) and solvent (H_2O) by means of filtration of the correlation signals with a double quantum filter.
Relayed-COSY or RELAY	5 mg	5 to 30 min	Magnetization transfer to 1 or 2 chemical bonds beyond those of the COSY transfer to determine coupled spin systems (only via J).
TOCSY	5 mg	5 to 30 min	Show correlation among all the spins that have a common coupling partner, e.g., A $\rightarrow$ B $\rightarrow$ C, where J_{AB}, $J_{BC} \neq 0$, BUT $J_{AC} = 0$.
NOESY	10 mg	1 to 2 hours	Stereochemical information via dipolar coupling using cross-relaxation (longitudinal); determination of chemical exchange processes.
ROESY	10 mg	1 to 2 hours	Stereochemical information via dipolar coupling using cross-relaxation (transversal); adequate for molecules with average MW in the range of 1000-3000 and/or when $\omega\tau_c \sim 1.12$ (where ω is the spectrometer frequency and τ_c the correlation time).
HETCOR (1-bond)	20 mg	1 to 2 hours	Heteronuclear assignment
HMQC/HSQC (1 bond)	10 mg	0.5 to 2 hours	Heteronuclear assignment using inverse detection, i.e., using ^{1}Hs to detect heteronuclear frequencies (more often) or using a nucleus with larger (to detect a low-(nucleus (e.g. use of ^{19}F to detect ^{13}C frequencies).
HETCOR (n-bond)	20 mg	4 to 12 hours	H-X long range heteronuclear assignment (via $^2J_{XH}$ and $^3J_{XH}$).
HMBC (n-bond)	10 mg	2 to 12 hours	H-X long range heteronuclear assignment (via $^2J_{XH}$ and $^3J_{XH}$) using inverse detection.
HMQC-TOCSY	10 mg	0.5 to 2 hours	H-X long range heteronuclear assignment (via $^2J_{XH}$ e $^3J_{XH}$) using inverse detection and protonated Xs
INADEQUATE	100 mg	24-72 hours	Establishes ^{13}C-^{13}C connectivities. For structural elucidation of organic molecules, it is the most powerful experiment, but with the lowest sensitivity.

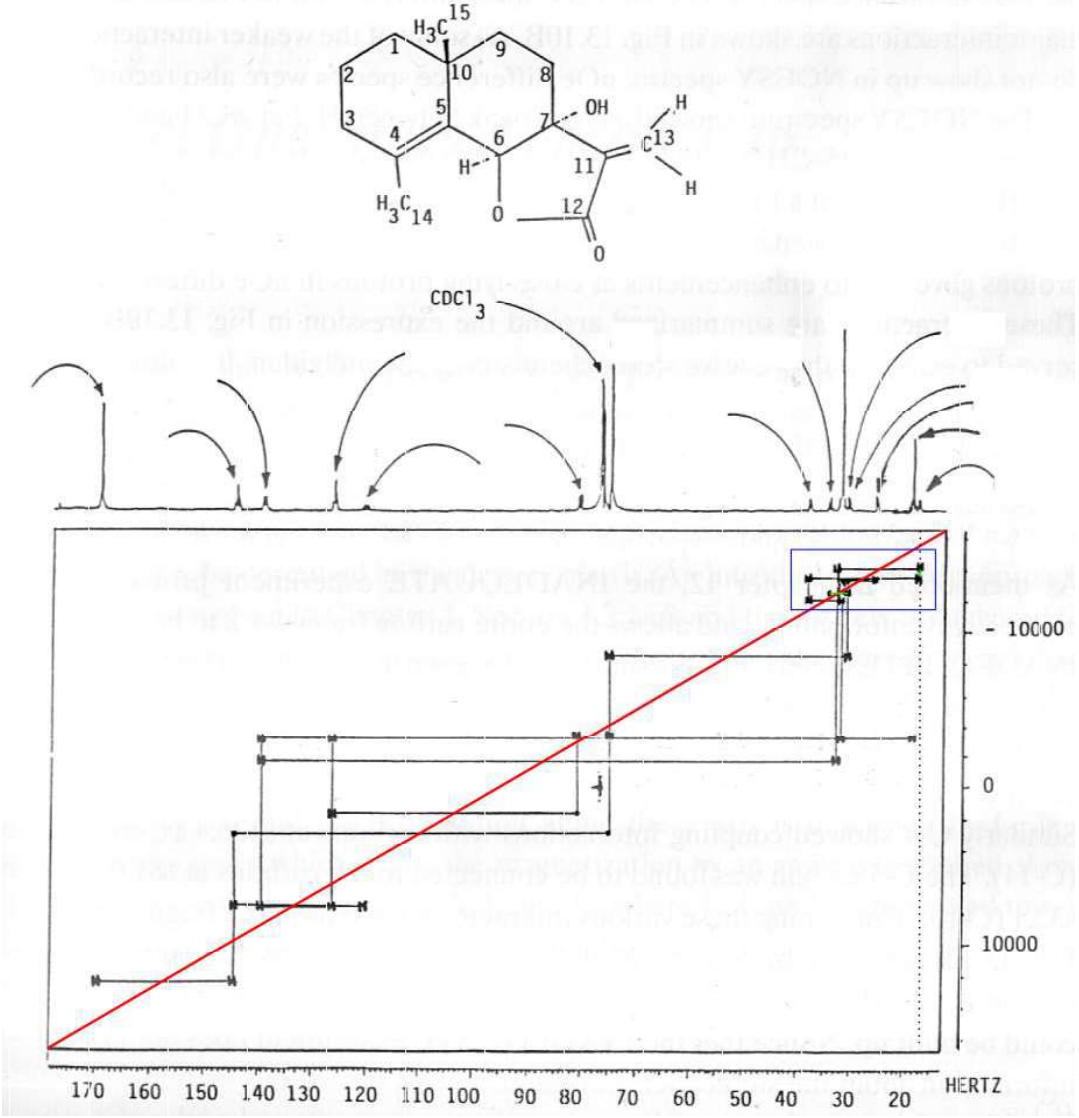
(*) The acquisition times and quantities mentioned above are for phase-cycled 2D experiments, i.e., experiments that require a minimum number of transients in F_2 to eliminate axial peaks and make quadrature detection. The experiments with pulsed field gradients tend to be faster than the phase-cycled ones.

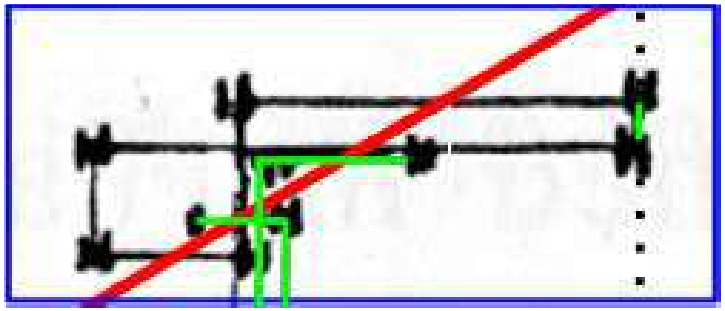
Benzothiazole Biodegradation: ^{1}H-^{15}N HMBC (*Appl. Environ. Microbiol.*, 2001, **67**)



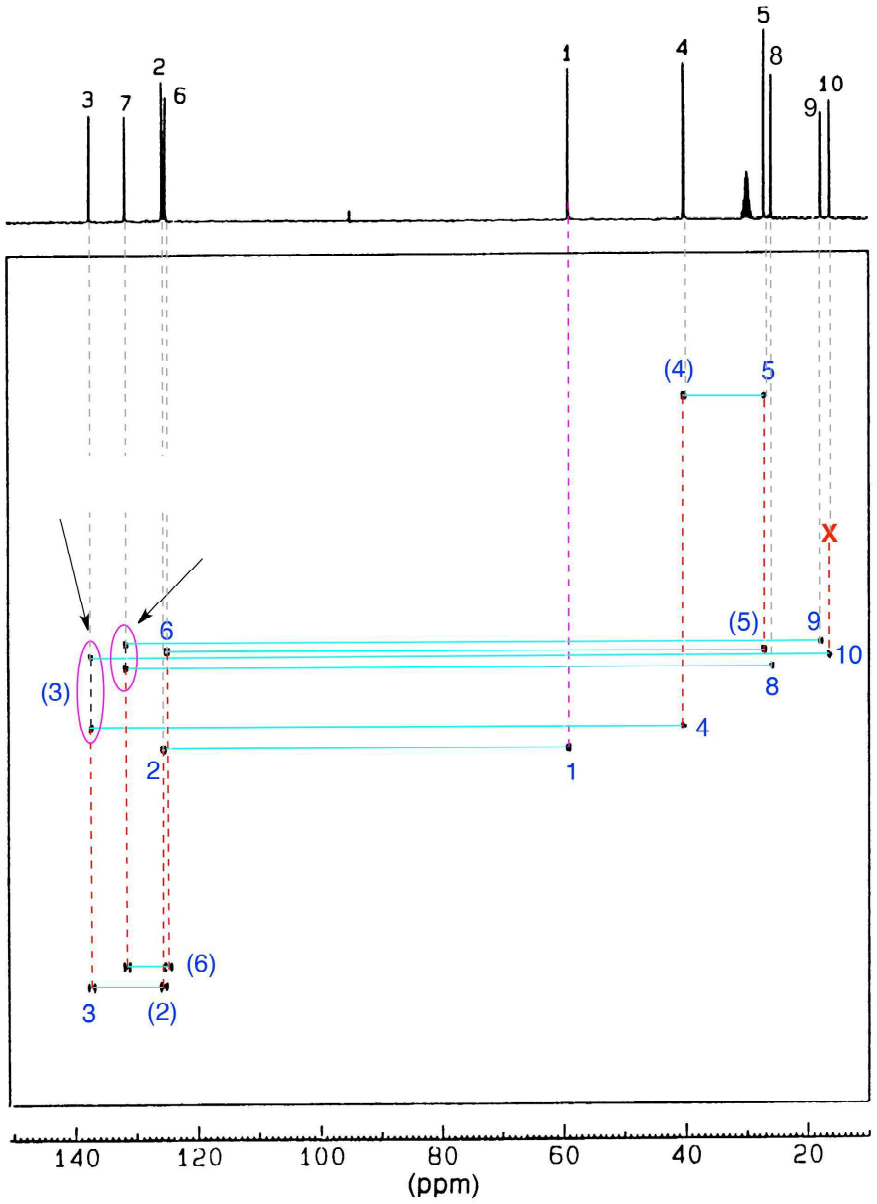


7-hydroxyfrullanolid - 2D ^{13}C INADEQUATE

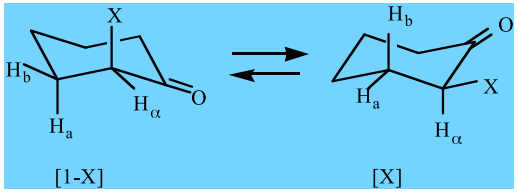




Determine the structure of $C_{10}H_{18}O$ using INADEQUATE exp.

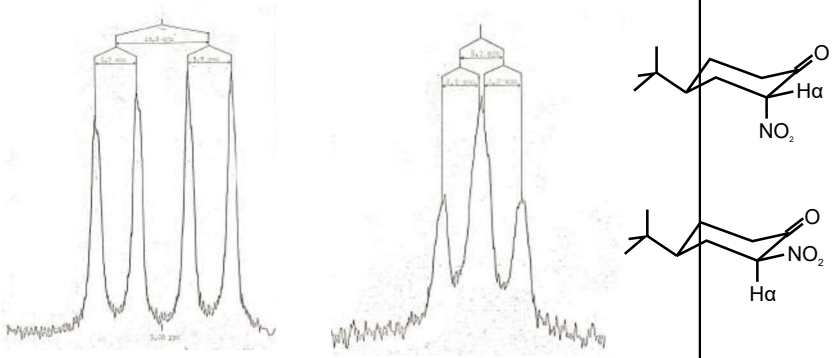


CALCULATING CONFORMATIONAL FREE ENERGY USING COUPLING CONSTANTS



The values of J_{aa}, J_{ee}, J_{ae} and J_{ea} are determined from Conformationaly rigid cyclohexanone systems

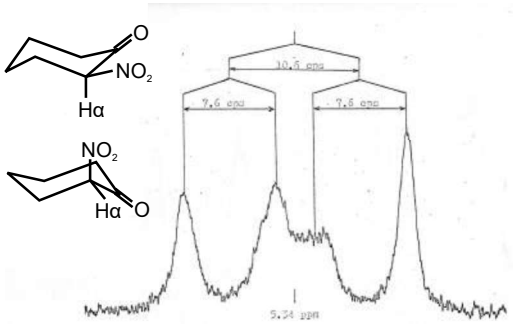
NMR OF 4-t-BUTYL-2-NITROCYCLOHEXANONE



J_{aa} = 12.6 Hz
J_{ae} = 5.7 Hz

J_{ea} = 5.2 Hz
J_{ee} = 4.3 Hz

NMR OF 2-NITROCYCLOHEXANONE



Average $J_{H\alpha Ha}$ = 10.6
Average $J_{H\alpha Hb}$ = 7.6

CALCULATING THE CONFORMATIONAL FREE ENERGY OF 2-NITROCYCLOHEXANONE USING COUPLING CONSTANTS