Measuring methods available and examples of their applications

COSY (COrrelation Spectroscopy)

The most frequently used two-dimension NMR experiment is the homonuclear correlation spectroscopy (COSY), which allows to identify spins which are coupled to each other.
The 2D spectrum that results from the COSY experiment shows the frequencies for a single isotope, most commonly hydrogen (^{1}H) along both axes. COSY spectra show two types of peaks. Diagonal peaks have the same frequency coordinate on each axis and appear along the diagonal of the plot, while cross peaks have different values for each frequency coordinate and appear off the diagonal. Diagonal peaks correspond to the peaks in a 1D-NMR experiment, while the cross peaks indicate couplings between pairs of nuclei (much as multiplet splitting indicates couplings in 1D-NMR).
Cross peaks result from a phenomenon called magnetization transfer, and their presence indicates that two nuclei are coupled which have the two different chemical shifts that make up the cross peak's coordinates. Each coupling gives two symmetrical cross peaks above and below the diagonal. That is, a cross-peak occurs when there is a correlation between the signals of the spectrum along each of the two axes at these value. One can thus determine which atoms are connected to one another (within a small number of chemical bonds) by looking for cross-peaks between various signals.
An easy visual way to determine which couplings a cross peak represents is to find the diagonal peak which is directly above or below the cross peak, and the other diagonal peak which is directly to the left or right of the cross peak. The nuclei represented by those two diagonal peaks are coupled.

The analysis of fine structure of the COSY crosspeaks allows extracting the J-couplings that carry information about dihedral angles.

The most common COSY experiment is COSY-90, in which the p1 pulse tilts the nuclear spin by 90°. Another modification is COSY-45. In COSY-45 a 45° pulse is used instead of a 90° pulse for the first pulse, p1. The advantage of a COSY-45 is that the diagonal-peaks are less pronounced, making it simpler to match cross-peaks near the diagonal in a large molecule. Overall, the COSY-45 offers a cleaner spectrum while the COSY-90 is more sensitive.

Another related COSY technique is double quantum filtered (DQF COSY). This experiment has the advantage that it gives a cleaner spectrum in which the diagonal peaks are in-phase with the crosspeaks.

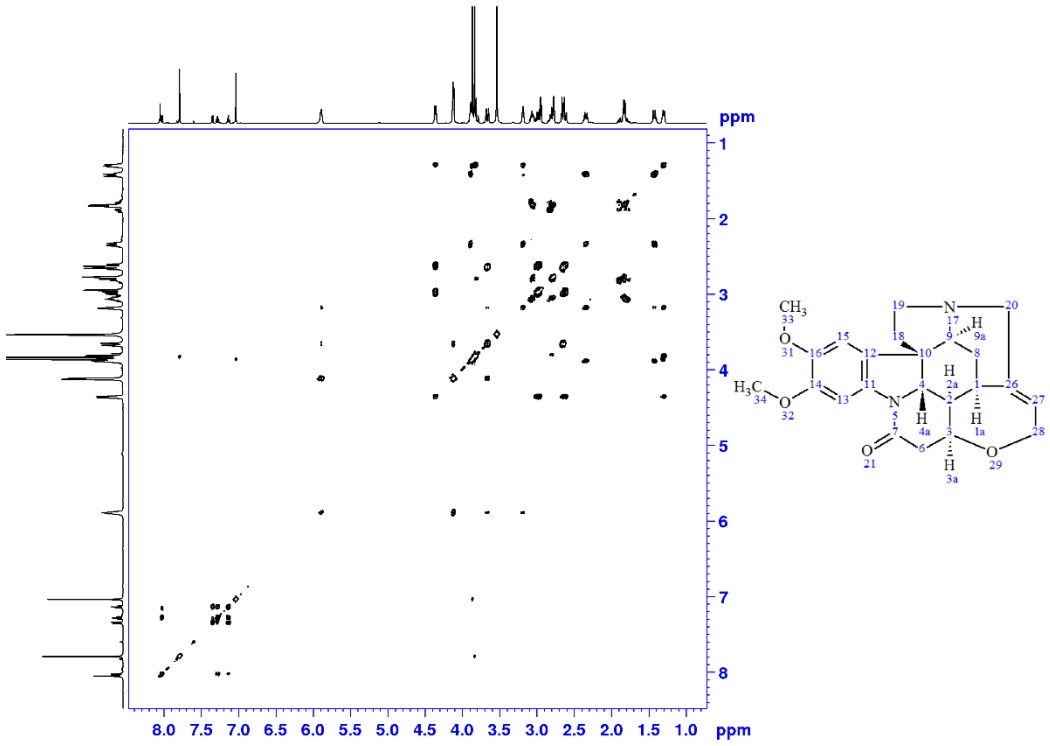

Fig. 1. ^{1}H COSY spectrum of Brucine in DMF-d7, gradient enhanced (magnitude mode)

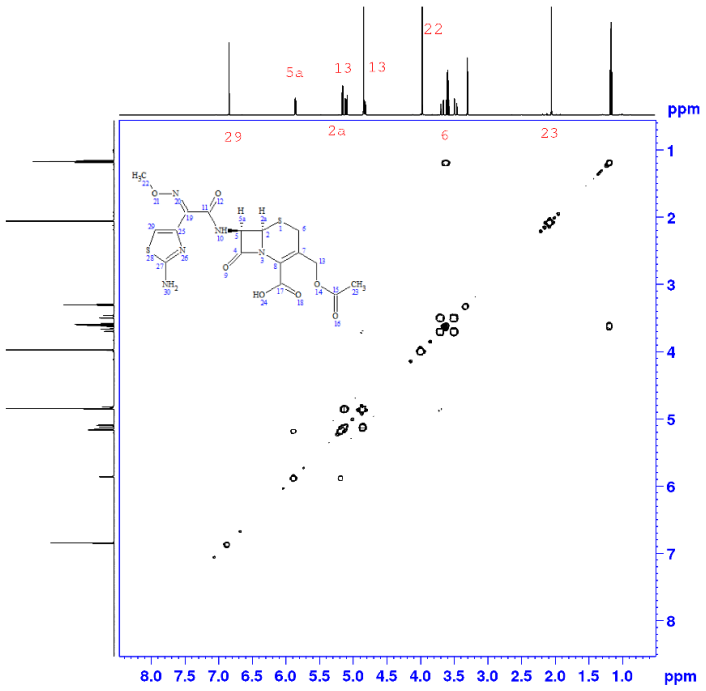

Fig. 2. Cefotaxime Acide (cephalosporin antibiotic), COSY 90 in MeOD-d4

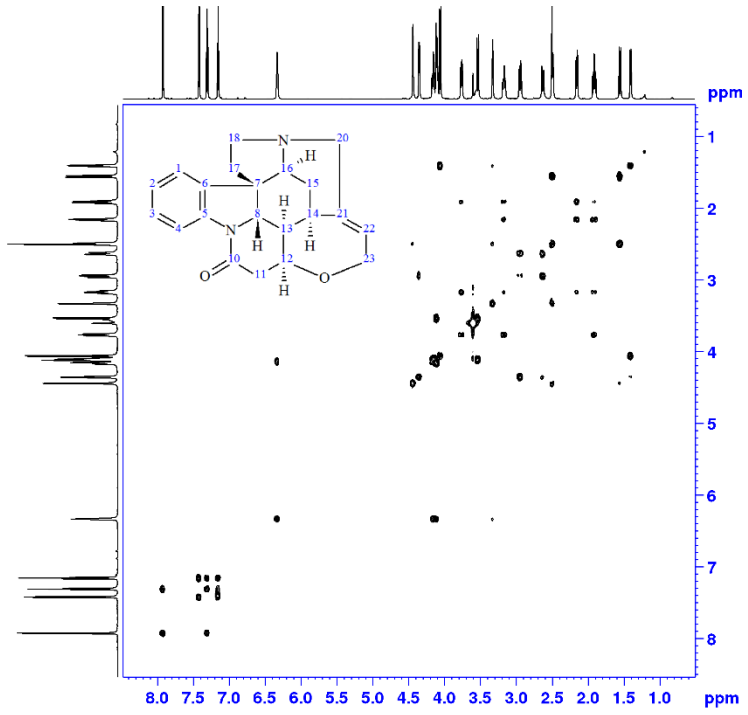

Fig. 3. Strychnine nitrate in DMSO-d6, gradient COSY (magnitude mode), Spectrometer: AVANCE III HD 700, Probehead: 5 mm Inverse Broadband with z-Gradients, Experiment time: 8 min