

Artemisinin

Artemisinin is a widely used drug in the standard treatment of malaria. It is extracted from the plant *Artemisia annua*, sweet wormwood, but can also be produced in a semi-synthetic fashion. Figure 1 shows the ¹H NMR spectrum of a 250 mM Artemisinin sample in CDCl₃ measured in a single scan taking 10 seconds to acquire.

1D Proton spectrum

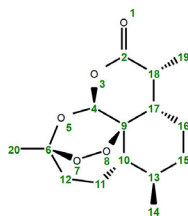


Artemisinin

Solvent = CDCl₃
 Concentration = 250 mM
 Frequency = 90 MHz

1D Proton

Number of scans = 1
 Repetition time = 10 s
 Pulse angle = 90°
 Total experimental time = 10 s



10 seconds

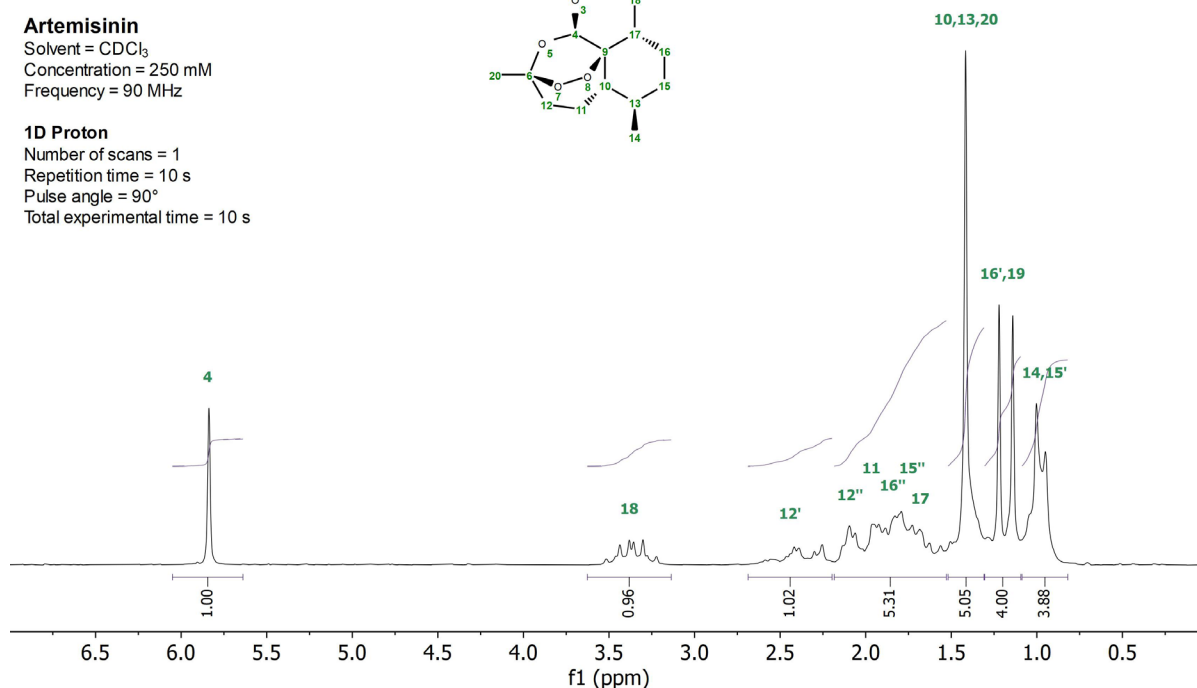


Figure 1: ¹H NMR spectrum of a 250 mM Artemisinin sample in CDCl₃ measured on a Spinsolve 90 MHz system in a single scan.

1D Carbon spectrum

Figure 2 shows the ¹³C NMR spectrum of 250 mM Artemisinin in CDCl₃ acquired using NOE polarization transfer from ¹H to ¹³C and ¹H decoupling. The 1D Carbon experiment using NOE is sensitive to all ¹³C nuclei in the sample. It clearly resolves all the expected resonances.

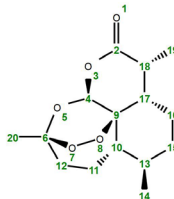


Artemisinin

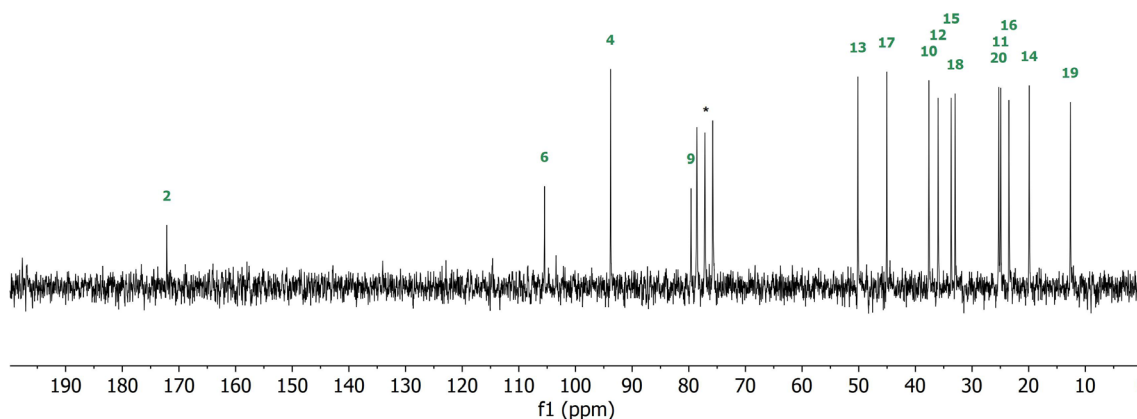
Solvent = CDCl₃
 Concentration = 250 mM
 Frequency = 23 MHz

1D Carbon

Number of scans = 2048
 Repetition time = 3.5 s
 Pulse angle = 45°
 Total experimental time = 120 min



120 min



* residual solvent

Figure 2: ¹³C NMR spectrum of a 250 mM Artemisinin sample in CDCl₃ measured on a Spinsolve 90 MHz system in 120 minutes.

2D COSY spectrum

The 2D COSY experiment allows one to identify coupled ^1H nuclei as they generate cross peaks out of the diagonal of the 2D data set. In Figure 3 a large number of cross peaks can be nicely observed. For example, the protons at position 4 and 17 (dark blue) couple with each other. Furthermore, proton 18 couples with proton 17 (cyan) and 19 (pink).



Artemisinin

Solvent = CDCl_3
 Concentration = 250 mM
 Frequency = 90 MHz

COSY

Number of scans = 1
 Total experimental time = 13 min

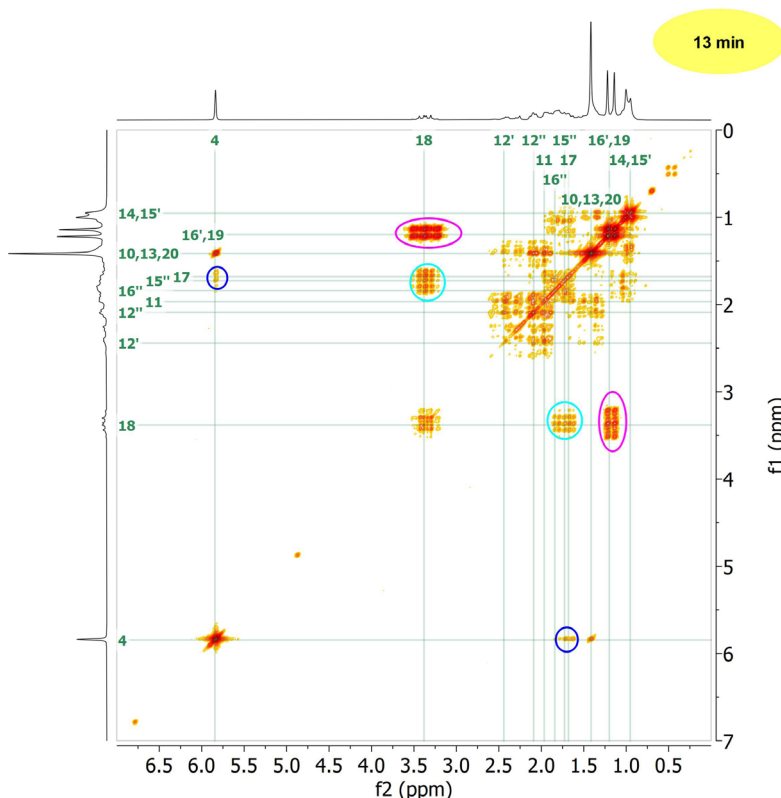
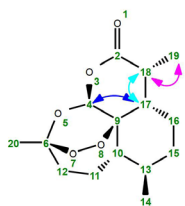


Figure 3: ^1H 2D COSY experiment of a 250 mM Artemisinin sample in CDCl_3 acquired in 13 minutes on a Spinsolve 90 MHz system.

2D HSQC-ME

The HSQC is a powerful sequence widely used to correlate ^1H with the one-bond coupled ^{13}C nuclei. The Spinsolve is equipped with a multiplicity edited version (HSQC-ME) of this method. It provides the editing power of the DEPT-135 sequence, which is useful to differentiate the signals of CH_2 groups (blue) from CH and CH_3 groups (red). Figure 4 shows the HSQC-ME spectrum of a 250 mM Artemisinin sample in CDCl_3 acquired in 8 minutes. The measurement time was optimized applying NUS (non uniform sampling).

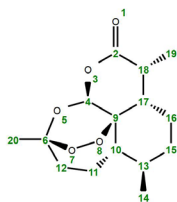


Artemisinin

Solvent = CDCl_3
 Concentration = 250 mM
 Frequency ^1H = 90 MHz

HSQC-ME

Number of scans = 2
 Repetition time = 1 s
 Number of steps = 512
 NUS = 50%
 Total experimental time = 8 min



Red = CH and CH_3

Blue = CH_2

* residual solvent

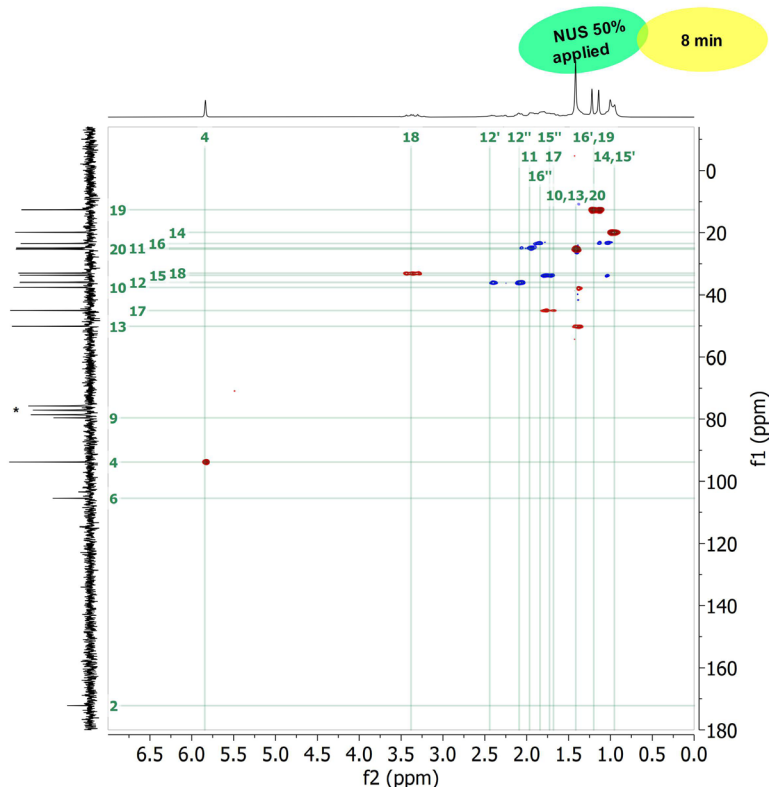


Figure 4: HSQC-ME spectrum of a 250 mM Artemisinin sample in CDCl_3 showing the correlation between the ^1H (horizontal) and ^{13}C (vertical) signals.

2D HMBC

To obtain long-range ^1H - ^{13}C correlations through two or three bond couplings, the Heteronuclear Multiple Bond Correlation (HMBC) experiment can be used. Figure 5 shows the HMBC spectrum of a 250 mM Artemisinin sample measured in 34 minutes on our Spinsolve 90 MHz. As an example, the long-range correlation of protons 19 with carbons 2, 17 and 18 are marked. The experiment shows the correlation with quaternary carbons, too.

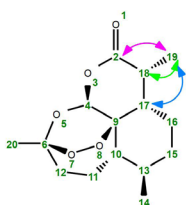


Artemisinin

Solvent = CDCl_3
 Concentration = 250 mM
 Frequency ^1H = 90 MHz

HMBC

Number of scans = 4
 Repetition time = 1 s
 Number of steps = 512
 Total experimental time = 34 min



* residual solvent

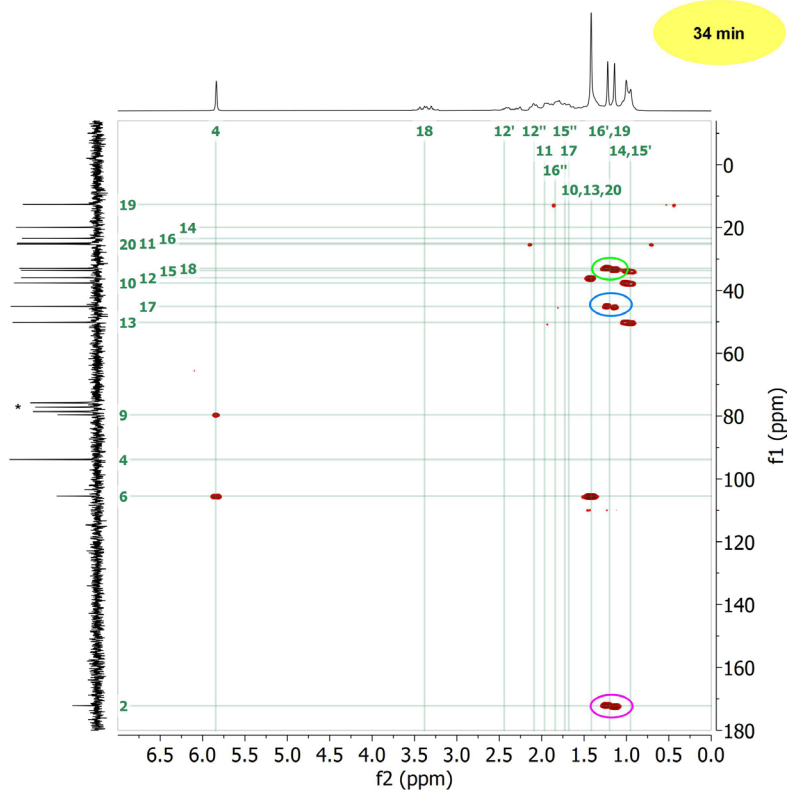


Figure 5: HMBC spectrum of a 250 mM Artemisinin sample in CDCl_3 showing the long-range couplings between ^1H and ^{13}C nuclei.