Shortening measurement time by multiple acquisition experiments

Product used : Nuclear Magnetic Resonance (NMR)

Multiple acquisition measurements have been attracting a lot of attention as a method for shortening measurement time in recent years. These sophisticated experiments allows us to acquire multiple 1D or 2D NMR data in one measurement on an instrument equipped with a single receiver or multiple receivers. Multiple acquisition experiments can significantly shorten the total experimental time compared to acquiring data conventionally.
In addition, multiple acquisition experiments can also benefit from Non Uniform Sampling (NUS), therefore additional shortening of measurement time is possible. However, if there is a significant difference in sensitivity between the experiments combined in the multiple acquisition experiment, it is necessary to set the number of scans according to the least sensitive experiment.

① NOAH method

NOAH (**N**MR by **O**rdered **A**cquisition using ^{1}**H**-detection) is a useful method which can acquire multiple 2D spectra at once even without using multiple receivers. Fig. 1 shows a NOAH pulse sequence which acquires 2D ^{1}H-^{13}C HSQC, ^{1}H-^{13}C HMBC and ^{1}H-^{1}H COSY spectra altogether. All the 2D spectra are generated simultaneously after the experiment has finished. Fig. 2 shows results of NOAH-3 of 10% cinnamic acid cis-3-hexen-1-yl ester in $CDCl_3$. These spectra can be obtained within 5 minutes by using NUS.
A dedicated automation was made for NOAH to improve its usability (Fig. 3). User sets the spectrum width, number of Y points, number of scans, and selects/unselects the NUS option. As individual filenames and process lists are automatically set for each data file after the measurement has completed, these data can be analyzed in the same way as traditionally acquired data.

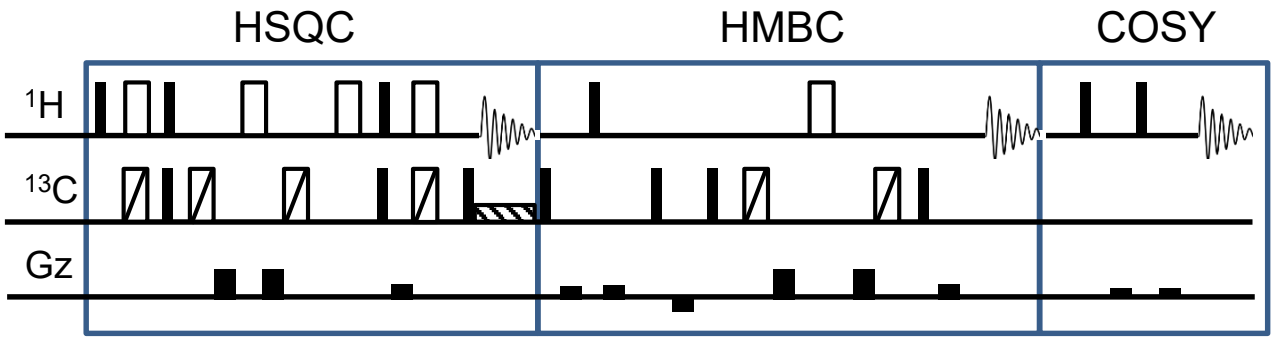


Fig. 1: Pulse sequence of NOAH-3

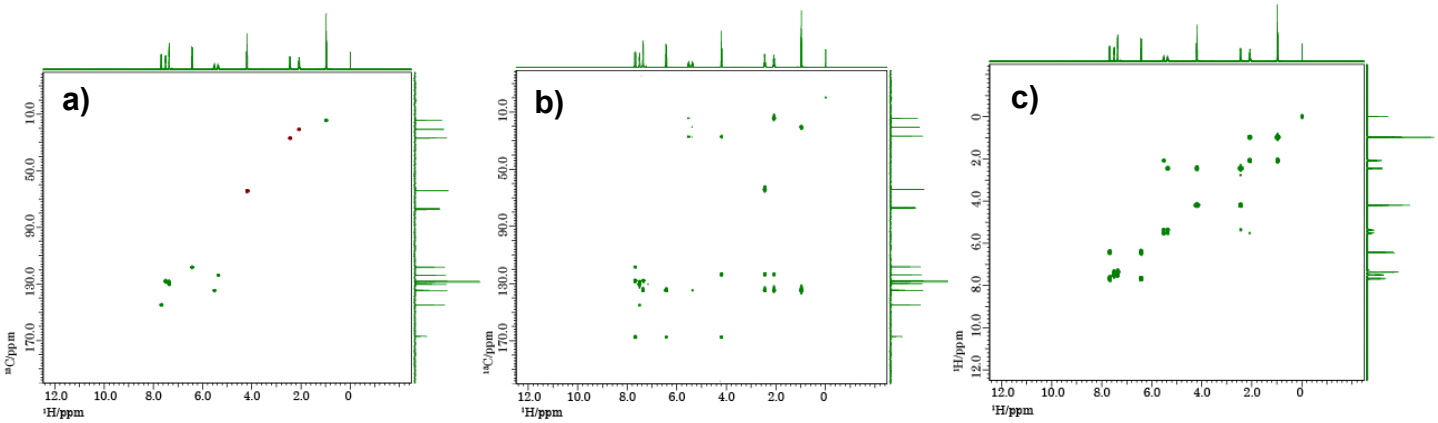
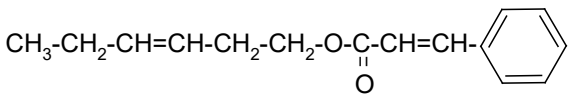


Fig. 2: NOAH-3: a) HSQC, b) HMBC, c) COSY
Number of scans: 1, Y points: 256, NUS density: 25%, exp. time: 5 min



Instrument : JNM-ECZ400S, ROYALPROBE™ HFX

Reference

Eriks Kupce and Tim D.W. Claridge, Angew. Chem. Int. Ed. Eng., vol. 56 (39), pp. 11779-11783 (2017).
JEOL Application Note NM190005

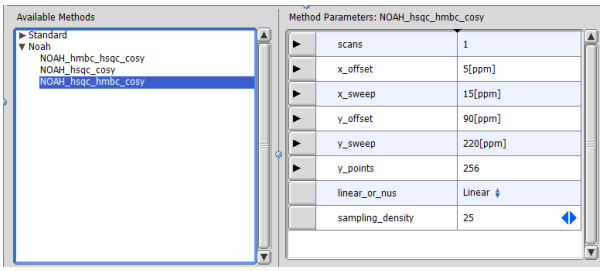


Fig. 3: Setting screen of NOAH automation

② Interleaved method

Interleaved experiments also have multiple acquisition blocks during one experiment. However, when compared to NOAH experiments, interleaved experiments detect different nuclei by means of multiple receivers.

Fig. 4 shows a pulse sequence of interleaved COSY. One receiver observes ^{1}H-^{1}H COSY and the second receiver observes ^{19}F-^{19}F COSY. Therefore, ^{1}H-^{1}H COSY and ^{19}F-^{19}F COSY spectra are recorded at the same time.

Fig. 5 shows results of interleaved COSY collected on 10 mg voriconazole in DMSO-d6. These spectra can be obtained within 3 minutes with NUS.

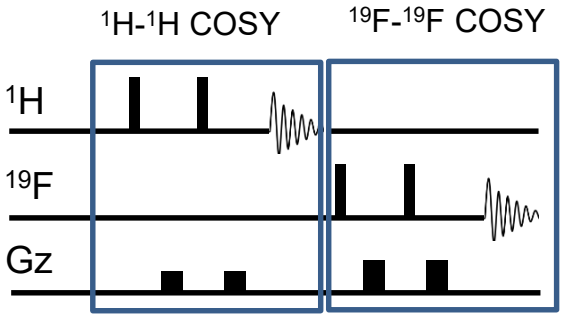


Fig. 4 : Pulse sequence of Interleaved COSY

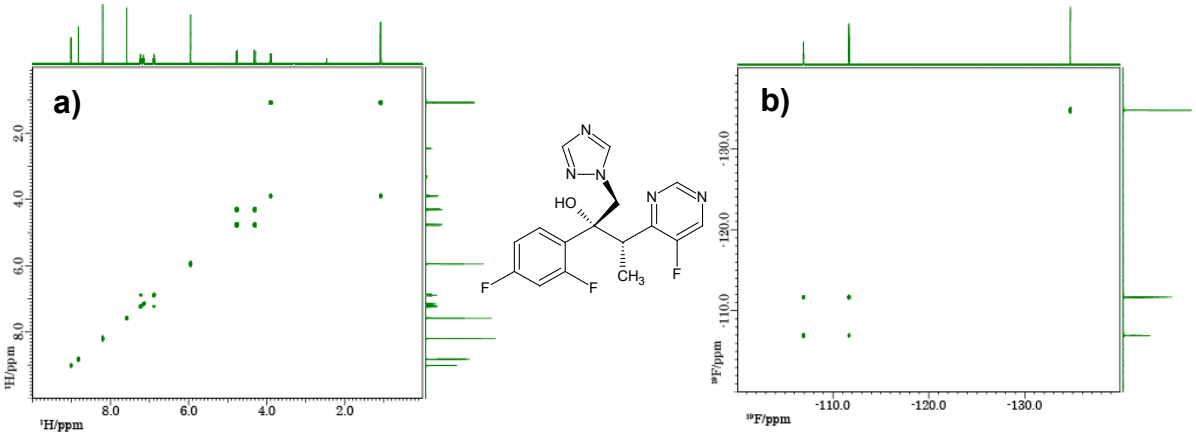


Fig. 5: Interleaved COSY: a) ^{1}H-^{1}H COSY, b) ^{19}F-^{19}F COSY
Number of scans: 1, Y points: 256, NUS density: 25%, exp. time: 3 min

Instrument : JNM-ECZ500R with HF2 extension, ROYALPROBE™ HFX

③ PANSY method

PANSY (Parallel Acquisition Nmr SpectroscopY) experiments usually acquire two FID data in parallel. These techniques also observe signal of different nuclei using multiple receivers as in the Interleaved method. On the other hand, acquisition blocks are executed at the same time, i.e. in parallel, in PANSY. Fig. 6 shows a pulse sequence of PANSY COSY which acquires ^{1}H-^{1}H COSY and ^{19}F-^{1}H HETCOR spectra.

Fig. 7 shows the results of PANSY COSY on 15 mg 1-ethoxy-2,3-difluoro-4-(trans-4-propylcyclohexyl)benzene in $CDCl_3$.

Fig. 8 shows a pulse sequence of PANSY HMBC which collects ^{1}H-^{13}C HMBC and ^{19}F-^{13}C HMBC spectra.

Fig. 9 shows the results of PANSY HMBC of the same sample. These measurements time were reduced by NUS.

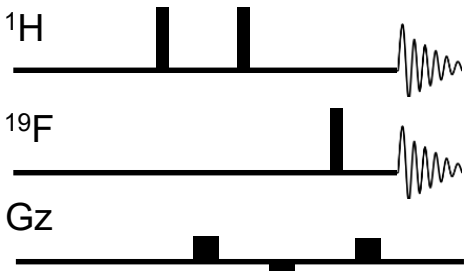


Fig. 6: Pulse sequence of PANSY COSY

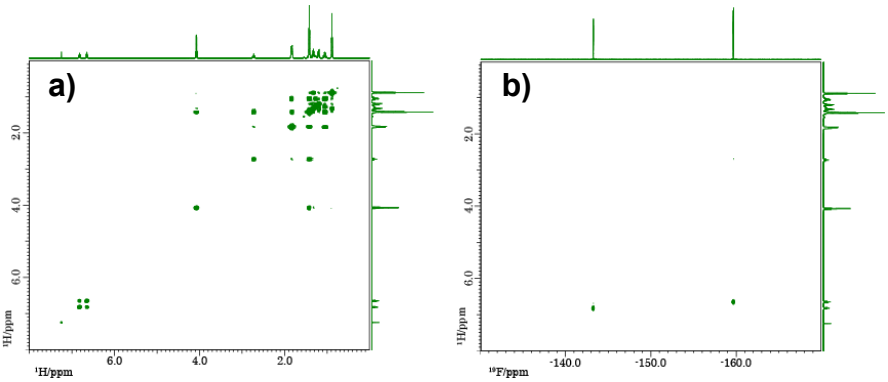
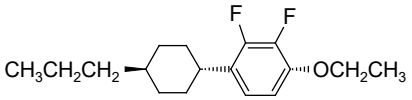


Fig. 7: PANSY COSY: a) ^{1}H-^{1}H COSY, b) ^{19}F-^{1}H HETCOR
Number of scans: 1, Y points: 256, NUS density: 25%, exp. time: 3 min



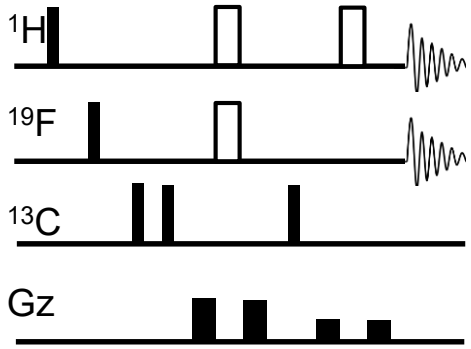


Fig. 8: Pulse sequence of PANSY HMBC

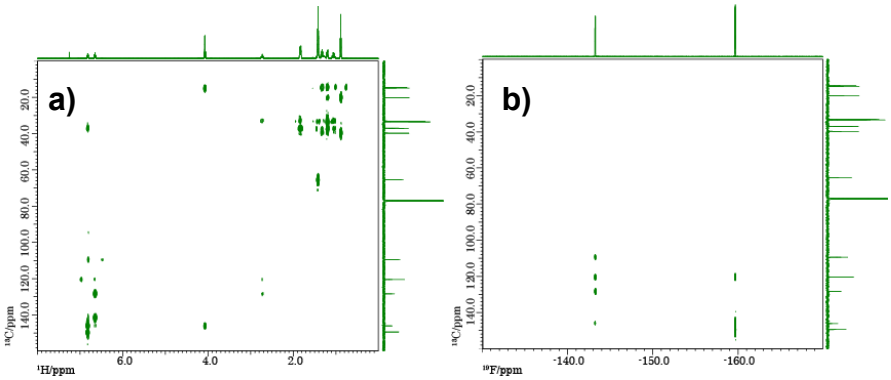


Fig. 9: PANSY HMBC: a) ^{1}H-^{13}C HMBC, b) ^{19}F-^{13}C HMBC
Number of scans: 4, Y points: 256, NUS density: 25%, exp. time: 8 min

Instrument: JNM-ECZ500R with HF2 extension, ROYALPROBE™ HFX

Reference of Interleaved and PANSY:

Helena Kovacs and Eriks Kupce, Magn. Reson. Chem. 2016, 54, 544-560.

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