A novel method to obtain high resolution 2D MRS through 3D acquisition under large inhomogeneous magnetic fields

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Target audience

The target audience of present study is the scientists who are interested in acquiring MRS in the tissues with high field inhomogeneity.

Purpose

In vivo magnetic resonance spectroscopy (MRS) allows noninvasive analysis of metabolites. High resolution MRS experiments are usually performed in homogeneous magnetic fields. However, filed homogeneity in vivo is often degraded by magnetic susceptibility variation near, for example, air/tissue interfaces. Intermolecular multiple quantum coherences have been utilized to achieved high resolution MRS under inhomogeneous fields.[1] However, intrinsic low signal intensity limits their practical application. Here, a new pulse sequence based on coherence transfer and spin echo is designed to obtain high-resolution 2D MRS via 3D acquisition in the presence of large field inhomogeneity.

Methods

The pulse sequence is shown in Fig. 1. All three pulses are non-selective, and two indirect evolution dimensions are utilized. High resolution can be achieved by tracking the differences of the precession frequencies of two spins in the F2 dimension, and spin echo is utilized for high resolution in the F1 dimension. The experiments were performed at 298K using an 11.7 T Varian NMR system spectrometer and a 5 mm indirect detection probe with three-dimension gradient coils. A sample of proanol ($CH_3CH_2CH_2OH$) was used to demonstrate the feasible of the new sequence. The magnetic field was intentionally deshimmed to produce a line width of ~2000 Hz (phased mode). The F1 spectral width was 50 Hz in 15 increments, and the F2 spectral width was 1100 Hz in 120 increments. The repetition time was 1 s, and the total acquisition time was about half an hour.

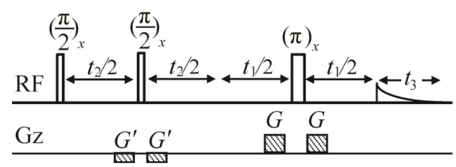

Fig. 1. Pulse sequence for acquiring 2D high resolution MRS under arbitrary inhomogeneous fields.

Results

Fig. 2b shows the conventional 1D ^{1}H spectrum under an inhomogeneous field of about 2000 Hz. There is no useful information which we can obtain from this spectrum. The sequence in Fig. 1 was performed in the same inhomogeneous field to obtain 2D high resolution MRS via 3D acquisition. The experimental result of projected 2D MRS is shown in Fig. 2c. The effects of inhomogeneous B_0 fields are removed in the both F1 and F2 dimensions. The F1 dimension in the resulting spectrum displays J coupling splitting, and F2 dimension chemical shift differences.

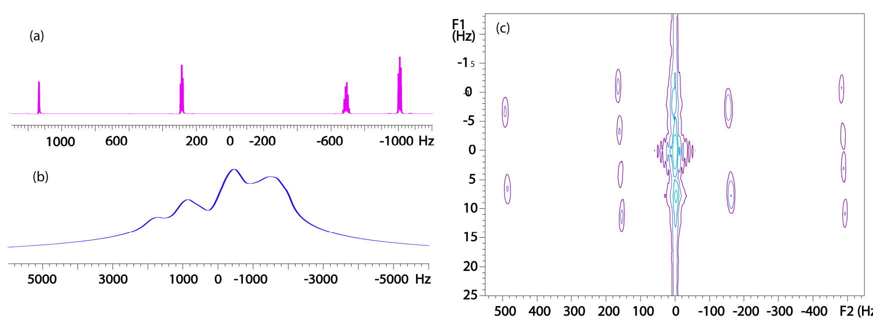

Fig. 2. (a) Conventional 1D ^{1}H high-resolution spectrum in a well-shimmed field, (b) conventional 1D spectrum acquired in an inhomogeneous field of about 2000 Hz line-width, (c) 2D high resolution spectrum using the scheme of Fig. 1 in the same inhomogeneous field as Fig. 2b.

Discussion

The experiment time was about half an hour under the current experimental setting. If one wants to obtain J coupling splitting information in the F2 dimension, the increment number in F2 dimension should increase and thus leads to further increase of experimental time. However, long experimental time is an obstacle for potential in vivo application. Compressed sensing technique[2] can be introduced to greatly reduce the scan time.

The sequence in Fig. 1 does not require any sophisticated gradient switching or frequency-modulated pluses[3], and only contains simple hard pulses and rectangular gradients. This would facilitate the potential in vivo study.

Conclusion

A new pulse sequence based on coherence transfer and spin echo is developed to refocus the effect caused by arbitrary inhomogeneous magnetic field. 2D high resolution MRS can be obtained using this new scheme even when the field inhomogeneities are severe enough to erase almost spectral information. The technique shown here can be applied potentially for in vivo high resolution MRS study with high field inhomogeneity.

Acknowledgments

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