3D Localized Direct ^{13}C Detection Using PRESS and a Modified DEPT Sequence

A. Yahya[1], P. S. Allen[1]

[1]Biomedical Engineering, University of Alberta, Edmonton, Alberta, Canada

Introduction

The method demonstrated here is a single scan method that acquires ^{13}C signal from a 3D volume by combining the single-shot PRESS localization sequence with a modified DEPT sequence [1]. This is a significant alternative to the more usual method of acquiring. Three dimensionally ^{13}C localized spectra that have been obtained localized proton signals using ISIS followed by DEPT polarization transfer [2-4]. The ISIS method of localization requires eight scans in order to define a voxel and thus is susceptible to motion artifacts and subtraction errors, whereas the technique demonstrated here is a single scan method.

Methods

The pulse sequence is shown in figure 1. Localization of transverse proton magnetization to the voxel of interest is performed by PRESS. DEPT polarization transfer is then used to transfer the magnetization from the protons to their coupled ^{13}C partners in that voxel. The spoiler gradients around both the ^{1}H and ^{13}C 180° pulses are additions to the original DEPT sequence to remove any off-resonance effects due to the imperfect refocussing pulses. They therefore relax the reliance on a phase cycling scheme [1]. Finally, the second ^{13}C 90° pulse, coherent with the ^{13}C excitation pulse transforms any ^{13}C signal that is directly excited by the ^{13}C excitation pulse into unobservable longitudinal magnetization. Therefore, we see that by combining PRESS with the modified DEPT sequence, the ^{13}C signal can be obtained from a 3D volume in a single scan.

All experiments were carried out using an 80cm bore, 3T magnet (Magnex Scientific PLC, Abingdon, UK) in conjunction with a SMIS console, a home-built 7cm diameter ^{1}H birdcage r.f. coil, and a 3.5cm diameter ^{13}C surface coil. The efficacy of the sequence was verified using two different phantoms each containing ^{13}C at natural abundance. The first was a double compartment spherical phantom containing 98% by volume, ethanol and 10M acetic acid, respectively, in a 3cm diameter outer compartment and a 1.5cm diameter inner compartment. A second single compartment spherical phantom contained 150mM glutamate (Glu) and 150mM glutamine (Gln). The pulse sequence was applied as shown in figure 1 with theta set to 45°. To enhance suppression of outer volume signal, a 16 step phase cycling scheme shown to be efficient for DEPT was incorporated into the sequence [5]. All experiments used the following parameters: TR = 3s, TE_1=10ms, and TE_2=10ms. For acetic acid $1/2J_{CH}$ was set to 3.85ms, and for Glu/Gln it was set to 3.7ms. The DEPT spoiler gradients were applied simultaneously in all three directions with amplitudes of approximately 2mT/m and were 1ms long. The ^{13}C nuclei were ^{1}H decoupled during acquisition using WALTZ-16.

Results

Figures 2 and 3 display the results obtained with the phantoms described above. Figure 2a shows a DEPT spectrum of the double compartment phantom with no localization, while figure 2b shows the result of applying the sequence as shown in figure 1, where the voxel was chosen to be an 8x8x8mm^3 cube centered in the inner compartment. The elimination of outer volume ethanol signal clearly demonstrates the localization efficiency. Figure 3 shows the response of the Glu/Gln phantom to the sequence indicating that the sequence is feasible for spin systems such as glutamate where the protons exhibit strong homonuclear coupling provided that the echo times of PRESS are minimized in order to minimize J-evolution during those times.

Conclusion

We have demonstrated that ^{13}C signal can be detected directly from 3D volumes in a single scan without the need to entirely rely on a phase cycling scheme or on the subtraction and addition of alternate scans by combining the standard PRESS localization sequence with a modified DEPT sequence.

Figures

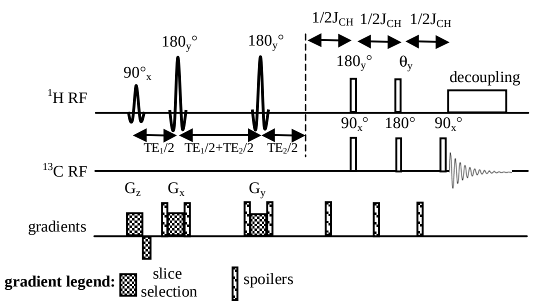

Figure 1: The combined pulse sequence

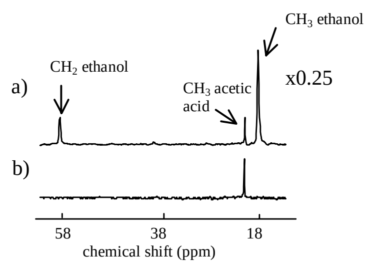

Figure 2: The top spectrum is a DEPT spectrum of the double compartment phantom with no localization. (b) is the spectrum obtained with the sequence shown in figure 1, from an 8x8x8mm^3 voxel centred in the inner compartment. All spectra were acquired in 128 averages.

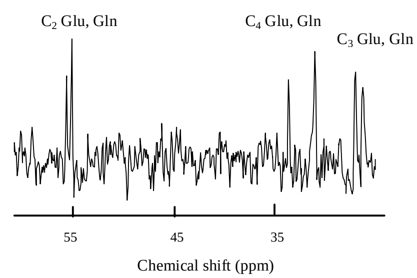

Figure 3: A proton decoupled spectrum from 4mL of the glutamate/glutamine phantom acquired using the described pulse sequence in 128 averages.

References

1. P. Henry, I. Tkac, R. Gruetter, *Magnetic Resonance in Medicine* **50**, 684 (2003).
2. R. Gruetter, E. Seaquist, S. Kim, K. Ugurbil,*Developmental Neuroscience* **20**, 380 (1998).
3. J. Shen, K. Petersen, K. Behar, P. Brown, T. Nixon, G. Mason, O. Petroff, G. Shulman, D. Rothman, *Proc. Natl. Acad. Sci. (USA)* **96**, 8235 (1999).
4. V. Lebon, K. Petersen, G. Cline, J. Shen, G. Mason, S. Dufour, K. Behar, G. Shulman, D. Rothman, *The Journal of Neuroscience* **22**, 1523 (2002).
5. D. Pegg, M. Bendall, *Magnetic Resonance in Medicine* **2**, 453 (1985).

Acknowledgements

The authors would like to thank the Canadian Institutes of Health Research, the Alberta Heritage Foundation for Medical Research, the Natural Sciences and Engineering Research Council of Canada and the Alberta Informatics Circle of Research Excellence.