A Strategy for 13C MRS Study of Human Frontal Lobes

N. Sailasuta[1], L. Robertson[2], K. Harris[1], and B. Ross[1]

[1]Huntington Medical Research Institutes, Pasadena, CA, United States, [2]Spin Dynamics, South Pasadena, CA, United States

Aim: Evaluate nuclear Overhauser effect (NOE) and proton decoupled ^{13}C MRS method using very low decoupling power for human study in the frontal lobes.

Background: Schizophrenia, HIV, drug abuse and several other common brain disorders involve frontal lobes structures. The application of proton-decoupled ^{13}C MRS method to study the brain metabolism in the frontal cortex is often prohibited due to the concern about potential damage to the eye from high power proton decoupling pulse. In order to perform such studies safely, very low or no power deposition is necessary, which in turn could result in poor carbon spectral resolution and low signal to noise ratio. In this study, we characterized NOE and proton decoupling efficiency of very low power (less than 1W) using three different types of random noise decoupling schemes in phantoms and in volunteer brain.

Method: All proton decoupled ^{13}C MRS experiments were performed on a 1.5T Signa scanner equipped with standalone proton decoupling hardware using vector signal generator (Agilent 4438C). Three random noise schemes were generated in Excel; ***scheme1*:** normal random numbers with mean of 10 and standard deviation (SD) of 25 with passthru filter, ***scheme2:*** normal random numbers with mean of 10 and standard deviation (SD) of 25 with Gaussian filter, and ***scheme3*:** pseudo random noise generation using Box-Muller method (2) with mean of zero and SD of one with Gaussian filter. These decoupling schemes were downloaded onto the vector signal generator and executed at several rates. Simple pulse and acquire data acquisition method was used. Bi-level low power pulses (0.1 to 2W) were applied to the proton channel for generation of NOE between excitations and for random noise decoupling during an acquisition time of 200msec with NOE to decoupling power ratio of approximately 1:10. Dioxane and ethyl alcohol were used to characterize the decoupling efficiency. The method was also tested in normal brain.

Results: Proton decoupled carbon spectra were recorded at -180, -100, 0, +100 and +200 Hz from the proton frequency of dioxane (3.69ppm) (Figure 1). The results of the three noise decoupling schemes are shown in Figure 1. Two different durations of the random noise execution of 5 and 3 K-vector (amplitude and phase) per second were tested and found the decoupling performances are not significantly different.

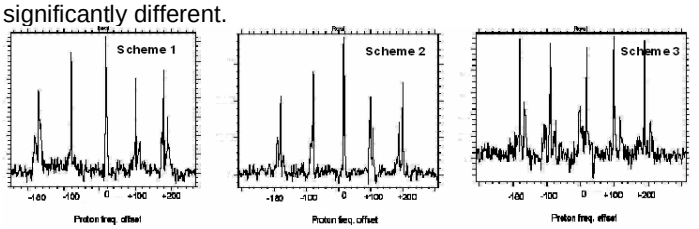
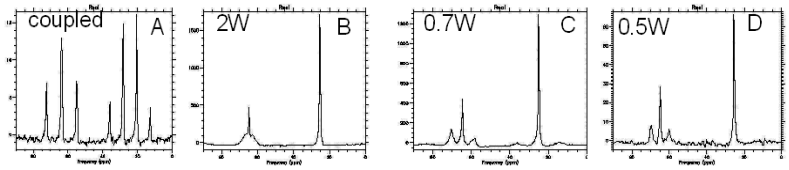


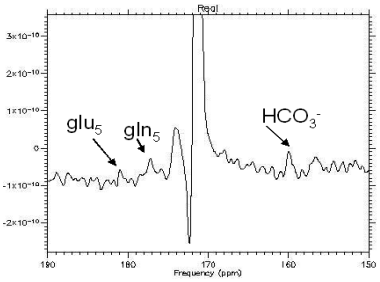
Figure1: 0.7 W noise decoupling profiles using scheme 1, 2 and 3.

To compare the efficiency of the decoupling, several power setting were tested using ethyl alcohol solution. The results obtained from the three different power settings using decoupling scheme 1 are shown in Figure 2 below.



The proton decoupling frequency was set on the CH_3 resonance.

A preliminary result in human brain is shown in Figure 3 (below). The 25 min proton noise decoupled carbon spectrum was recorded approximately at 120 min after start of C1-^{13}C glucose infusion in our current glutamate brain metabolism study in the parietal lobe using high power WALTZ 4 decoupling protocol. Random noise scheme 2 with 0.9W decoupling power was used. The non-protonated C5 glutamate resonance at 182ppm and HCO_3^- at 161ppm are clearly visible.



Discussion: Our results clearly demonstrate the feasibility of using low power NOE and pseudo noise decoupling and obtain a reasonable carbon spectrum with good resolution. Low power proton decoupling has been previously used to study the turnover of C2-^{13}C glucose into C5 Glu and Gln in monkey brain (2). In rat brain, C5 Glu, Gln and ^{13}C bicarbonate were determined to assay metabolic flux rates (3), while the same enriched pools were determined in posterior parietal region of human subjects (4). Our recent experience predicts that similar rate will be safely obtained from frontal brain structure implicated in many neurological and psychological brain disorders. Further application of this method to study brain metabolism is currently under way in our laboratory.

References: 1). Golder, ER, et al. 1976, 25(1): p 12-20. 2) Li, S. et al. Magn Reson Med, 2007. 57(2): p. 265-71. 3) Kanamori et. al. J Neurochem 2002. 83 p 682-695. 4) Bluml S et al. NMR in Biomed 2002. 15 p 1-5.

Acknowledgements: Supported by NIDA K2521112 (NS),NARSAD the Mental health Research Association (KH), NIH NS4589 (BD).