Evaluation of Carbon MRI at 21.1 T

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Introduction

Carbon is one of the most widespread nuclei in nature and, consequently, in vivo. Being the basis of organic molecules, it can convey valuable information about many biochemical reactions in vivo. However, the natural abundance of MR detectable carbon-13 is only 1.07%. As a result, it has one of the weakest in vivo MR signals, it is ~ 130 million times less sensitive than proton MR signal or 23,000 times less than sodium signal from our body. Thus, the question is what is our likelihood to perform carbon MRI to acquire carbon spatial information at the ultra high magnetic field of 21.1T?

Experimental

Experiments were performed at 21.1T magnet using in vivo rat probe and sodium/proton RF coil. Two test samples were used: solution of 99% enriched carbon-13 D-glucose (0.5 M) in 3 mL vial and 99% enriched sodium formate (150 mM) in a shaped sample serving for sodium and carbon MRI.

Results and Discussion

The sodium part of the double tuned sodium/proton RF coil was retuned from sodium (237.6 MHz) to carbon frequency of 226 MHz. The parameters for the carbon coils were very close to that of sodium MRI and duration of the 90 pulse was also the same ~ 100 µs.

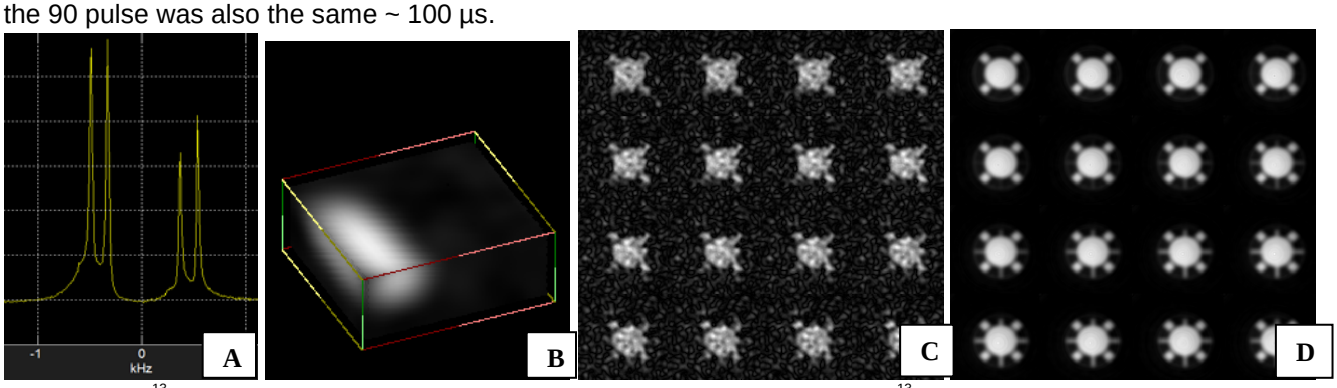

Figure 1. (A) 1-^{13}C MR spectrum of β- (left) and α- (right) isomers of D-glucose at 21.1 T; (B)1-^{13}C 3D-CSI image of D-glucose solution. Saline solution placed at the right side of the glucose sample is not noticeable; (C) carbon MRI of 150 mM formate solution and sodium MRI (D) of the same sample, resolution 2x2x2 mm.

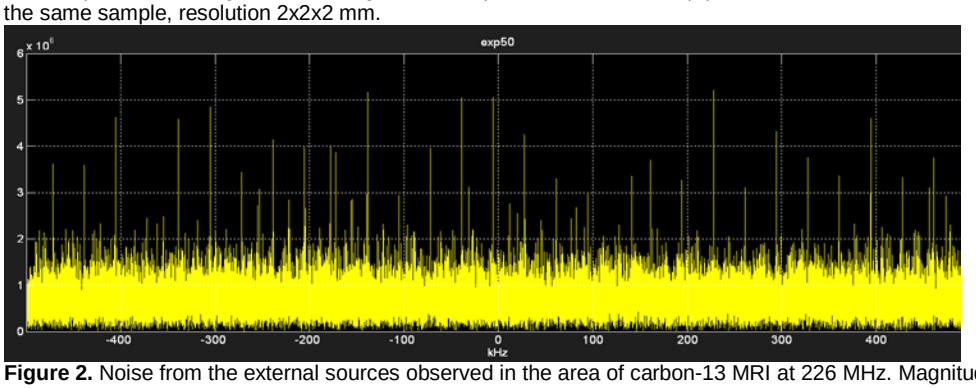

Figure 2. Noise from the external sources observed in the area of carbon-13 MRI at 226 MHz. Magnitude of the spectrum (width = 1 MHz, NP=32K, NA=1) demonstrates multiple noisy peaks visible above thermal noise.

Conclusions

The results demonstrate capability to perform MRI of carbon-13 at 21.1T using volume RF coil. The present sodium/proton RF coil can be tuned for detection of carbon MRI allowing to perform MRI experiments for three nuclei on the same animal without repositioning, which can dramatically improve efficiency of multinuclear *in vivo* experiments. The current shielding of the MRI gradient coils needs further improvement to achieve full capability of carbon MRI in future.

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