Development of ^{13}C R.F. coils and MR sequences for dissolution DNP experiments

Collins, J.H.P. (UF, Biochemistry); Elumalai, M. (UF, MBI); Downes, D.P. (UF, Biochemistry); Lama, B. (UF, Biochemistry); Long, J.R. (UF, Biochemistry); Cheng, T. (EPFL, IPSB); Comment, A. (EPFL, IPSB)

Introduction

Combining MR imaging techniques with dissolution dynamic nuclear polarization (DNP)[1] will greatly enhance the potential of *in-vivo* studies and allow spectral spatial imaging of ^{13}C labelled metabolites. There is a signal enhancement of up to 16,000 times thermal equilibrium (4.7 T MRI, AMRIS, UF). However, the polarization quickly returns to thermal equilibrium and the injected metabolite is significantly diluted within the blood stream. Depending on the requirements of the study, for example studying specific muscle groups, only a small percentage of the injected metabolite may be present in the region of interest (ROI). Thus to maximize the signal to noise ratio (SNR), specific MR coils are being developed for specific measurements. The three coils developed so far are a 10 mm i.d. dual resonance ^{13}C/ ^{1}H saddle coil, a 25 mm i.d single resonance ^{13}C coil, and a dual-channel 60 mm i.d. birdcage ^{13}C transmit only coil[2]. Copies of the coils for the 4.7 T and 11 T MRI systems are being developed, and a 9.4 T version of the 60 mm coil was produced in collaboration with the EPFL. The dual resonance 10 mm coil is specified for measurements on a mouse leg. A small scale (3 ml volume) flow-through bioreactor has also been developed for use with this coil. The 25 mm ^{13}C coil is designed for studying a rat leg, and has a significantly improved filling factor. Finally, the transmit-only coil (Fig. 1) is being developed for spectroscopic imaging application. The transmit-only volume coil is coupled with a receive-only ^{13}C surface coil, and thus combines the R.F. homogeneity of a volume coil, with the higher sensitivity of a surface coil[3]. A separate ^{1}H surface transceive coil will be used for shimming the sample.

Experimental

Testing of the developed R.F. coils has begun on the 4.7 T MRI at the UF, AMRIS facility. Special 'rat' phantoms, which mimic the loading and ^{13}C signal of the metabolites, have been previously developed for the 60 mm coil, while the smaller 10 mm and 25 mm coils have been tested with phantoms of ethanol, as well as live cultures of BL21 *E.coli*. The *E.coli* cultures were injected with hyperpolarized sodium pyruvate [1 – ^{13}C], and a time sequence of ^{13}C spectra acquired for 10 minutes after the injection.

Results and Discussion

The 10 mm and 25 mm coils have been successfully tested, and show good SNR and R.F. performance. An example of the spectra acquired from *E.coli* culture is shown in Fig. 2. The various metabolites show good spectral separation allowing them to be easily distinguished. Further testing of the coils performance with the bSSFP imaging sequence, and comparisons of SNR obtained at the different field strengths is ongoing.

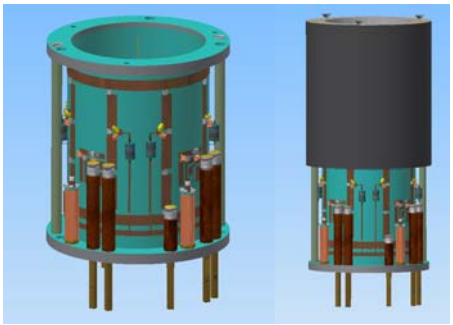

Fig.1 Autodesk Inventor design schematic of TX only coil

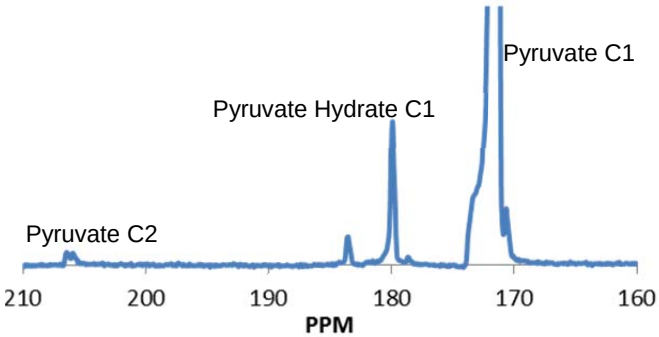

Fig.2 Sample *E.Coli* phantom data from 10 mm coil

Acknowledgements

A portion of this work was performed at the National High Magnetic Field Laboratory, which is supported by National Science Foundation Cooperative Agreement No. DMR-1157490, the State of Florida, and the U.S. Department of Energy.

References

[1] Ardenkjaer-Larsen, J. H. *et al.,* Proc. Natl. Acad. Sci., **100**, 10158 – 10163 (2003)
[2] Beck, B.L., *et al.,* Proc. Intl. Soc. Mag. Reson. Med. **19**, 1853 (2011)
[3] Garbow, J.L., *et al.,* Concepts Mag. Reson. B. **33B**, 252 – 259 (2008)