Development of a ^{13}C Volume Coil for Ultra-High Field Metabolic Imaging Via Dissolution Dynamic Nuclear Polarization

Cheng, T.; Comment, A. (EPFL, Physics); Elumalai, M.; Collins, J.; Long, J. (NHMFL, AMRIS)

Introduction

Dissolution dynamic nuclear polarization (DNP) leads to tremendous ^{13}C magnetic resonance (MR) signal enhancement and allows for real-time metabolic imaging [1-3]. For detecting hyperpolarized ^{13}C signals, excite/receive surface coils provide higher signal-to-noise ratio (SNR) than volume coils because of their close proximity to the region of interest (ROI). However, the inherent radiofrequency (RF) excitation field (B_1) inhomogeneity limits the use of advanced pulse sequences because the adiabatic pulses required to compensate for this inhomogeneous excitation are long and have ill-defined off-resonance behavior. The aim of the present project was to develop a new tailored excite/receive ^{13}C birdcage coil with a 78 mm inner diameter adapted *for in vivo* measurements in rodents at 9.4 T with high B_1 homogeneity and high sensitivity.

Experimental

The quadrature volume coil was designed by the RF team of the AMRIS facility. It is based on a low-pass type birdcage structure. RF baluns were implemented to reduce the coupling between the two RF channels. Bench tests to determine parameters such as quality factor and coil detuning were carried out after the coil was built, tuned and matched to the targeted frequency (100MHz). Using a Gd-doped 1M [1-^{13}C] acetate phantom (25mm OD), RF calibration and B_1^+ field mapping were performed in the 9.4T preclinical MR scanner (Varian, USA) located at EPFL, Switzerland. To generate B_1^+ field maps, the double angle method [4, 5] was used to compare the signal intensity from two gradient echo (GRE) images with flip angle of α and 2α, respectively. The ROI in the phantom was shimmed using the FASTESTMAP method before recording the ^{13}C images [6].

Results and Discussion

The ^{13}C images displayed an excellent RF homogeneity, and it was possible to flip the ^{13}C magnetization by 90° with a 350μs-long hard pulse and less than 200W. B_1^+ field maps were recorded in both axial and coronal planes with an in-plane resolution of 2 x 2 mm^2 (Fig.1). The geometry of the coil is well adapted for *in vivo* measurements in rodents. This probe is currently being tested in hyperpolarized MR spectroscopy (MRS) and imaging (MRI) experiments.

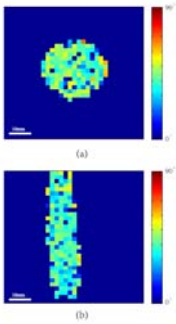

Figure 1. B_1^+ field maps recorded at 9.4T in a ^{13}C-acetate phantom with the tailored ^{13}C birdcage coil: (a) axial and (b) coronal directions. Images were acquired with a 2 x 2 mm^2 in-plane resolution.

Conclusions

Through the joint effort of the NHMFL AMRIS facility and the EPFL, a highly performant ^{13}C excite/receive birdcage coil was implemented and tested. It will be used for real-time metabolic imaging in small animal using ^{13}C-labeled substrates hyperpolarized by dissolution DNP. Further implementation include a RF detune board for switching the coil to excite-only mode and adapt a ^{13}C surface coil for detection.

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