Development of MRI Sequences Optimized for Use with Dissolution DNP

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Introduction

Combining MR imaging techniques with the recently developed method of 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. To this end ^{13}C labeled 'rat' and 'mouse' phantoms, which have similar dielectric properties to their respective animals, are being developed. These will allow testing and optimization of the imaging sequences being implemented. Several different imaging sequences have been utilized by other researchers to image hyperpolarized metabolites, which include balanced steady state free precession (bSSFP)[2,] localized spectroscopy using double spin-echo EPSI[3], and novel k-t spiral k-space acquisition trajectories[4]. These sequences will be implemented and optimized on the local 4.7 T and 11.1 T spectrometers.

Experimental

A prototype 'rat' phantom consisting of a 50 ml Falcon™ tube filled with previously developed 'abdomen' tissue equivalent mixture[5]. Plastic inserts were manufactured to hold 3 flame-sealed 5 mm NMR sample tubes, containing D_2O solutions of 1 M ^{13}C labeled Sodium Acetate, Sodium Butyrate, and 0.5 M Sodium Pyruvate. Initial testing of the prototype using standard proton rapid 2D spin-echo and gradient-echo imaging has been performed.

Results and Discussion

Proton imaging of the phantoms are used to confirm no significant transfer solute from the sealed NMR tubes to the surrounding water based 'abdomen equivalent' mixture. The proton images also provide a structural 'anatomic' map which is used to confirm the positioning of the NMR tubes filled with ^{13}C labeled metabolites. An example of the proton image is shown in Fig. 1. The enhancement of signal due to the DNP hyper-polarization is approximately 10,000[1]. The injected concentration of metabolite is on the order of 0.1 M, and can constitute 10% of the total blood volume of the study animal. We can expect the tissue concentration to be 10% of the plasma concentration, giving an effective tissue concentration of 1 mM. With the DNP enhancement of 10,000, this should have a similar NMR to 10M thermally polarized metabolite.

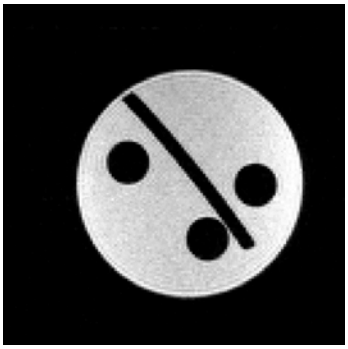

Figure 1: spin-echo image of a 2 mm thick transverse slice through the phantom. In-plane isotropic resolution of the image is 0.31 mm^2, and has dimensions of 40 mm × 40 mm.

Conclusions

A 'rat' phantom for developing ^{13}C hyperpolarized imaging strategies has been developed. The concentrations of metabolite are such that imaging sequences relevant to *in-vivo* hyperpolarized imaging. Estimates from the likely tissue concentration of metabolites suggest the signal-to-noise ratio in the in-vivo studies will be an order of magnitude better than achieved on the phantom.

Acknowledgements

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References

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