Low RF-field strength cross polarization combined with photo-induced non-persistent radicals for clinically applicable dDNP

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Low RF-field strength cross polarization combined with photo-induced non-persistent radicals for clinically applicable dDNP

Work in progress

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Cross Polarisation for SPINlab-like polarisers using non-persistent radicals is demonstrated.

The efficiency of the transfer from protons to carbon is modest at the currently achievable low B fields of 4-5 kHz still yielding ¹³C polarisation levels up to 15%. Based on the presented results, we foresee polarisation levels superior to direct ¹³C DNP in our next generation of double-tuned probes incorporating local tune and match.

Abstract

We demonstrate the possibility of ¹H Dynamic Nuclear Polarization followed by cross polarization to carbon (DNP-CP) using a modified low cost benchtop console (Kea2) equipped with an external amplifier (Tomco) and a SPINlab-like dissolution DNP polarizer i.e. using the same fluid path and allowing for hyperpolarisation of a full human dose. Cross polarization (CP) using Laboratory Frame De- and Remagnetisation (LAFDR) was found superior to alternative sequences at the limited B₁ fields employed. Faster build-up rates compared to ¹³C DNP are demonstrated using TEMPOL (4-Hydroxy-2,2,6,6-tetramethylpiperidine 1-oxyl) and DNP-CP ¹³C polarisations up to 15 % are achieved using non-persistent UV-induced radicals.

Introduction

Dissolution Dynamic Nuclear Polarization (dDNP) is used to enhance the MR signals in imaging by factors of 10,000 ² paving the road for metabolic MR studies. However, the polarisation build-up on ¹³C typically takes tens of minutes to hours, significantly lowering the versatility and throughput. Recently, studies have shown the possibility of speeding up the process by polarizing ¹H, which has a faster build-up, followed by polarization transfer to, e.g. ¹³C.³ However, strong B₁ fields and small sample volumes are used, which makes the technique incompatible with clinical dDNP-MRI. Moreover, for clinical use, and in general to eliminate the relaxation effect, the radical essential for DNP needs to be removed during dissolution. Use of pyruvic acid (PA) non-persistent photo-induced radicals for dDNP has been demonstrated to solve this issue⁴ and recently polarization build-up on protons with ¹H up to 690 s and 70 % polarization has been presented⁵.

Methods

Overview

Experimental results

DNP-CP using TEMPOL as radical

DNP-CP using UV-induced radicals

Conclusion and Outlook

We have demonstrated DNP-CP on a clinical-compatible SPINlab-like polarising using a low-cost benchtop console equipped with an external amplifier. Moreover, the technique has been combined with non-persistent UV-induced radicals. At the current state, with B¹≤5 kHz, direct ¹³C DNP still outperforms the DNP-CP. However, the goal is to implement local tuning of the probe to achieve sufficient B₁ fields to increase the transfer efficiency. We expect that sufficiently strong B₁ fields are achievable for this setup to outperform direct ¹³C DNP both with respect to build-up rates and polarisation levels.

References