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 B₁ 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 ¹³C Dynamic Nuclear Polarization followed by cross polarization to carbon (DNP-CP) using a modified low cost benchtop console (Kea2) equipped with an external amplifier (Tomo2) and a SPINlab-like dissolution DNP polarizer i.e. using the same fluid path and allowing for hyperpolarisation of a full human dose. Cross polarisation (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 or paviing 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 ¹³C, which has a faster build-up, followed by polarization transfer to e.g. ¹H.² However, strong B₁ fields and small sample volumes are used, which makes the technique incompatible with clinical dDNP-MRI. Moreover, when used, 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 issue³ and recently polarization build-up on protons with ¹H prep – 690 s and 70 % polarization has been presented⁴.

Methods
Overview

Results
The efficiency of DNP-CP depends on the build-up rate and final polarisation achieved on protons as well as the transfer efficiency of the CP sequence.

Conclusion and Outlook
We have demonstrated DNP-CP on a clinical-compatible SPINlab-like polariser 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

Figure captions

CP by Laboratory Frame De- and Remagnetisation (LAFDR)