Hyperpolarized Metabolic MR – a new imaging modality for studying metabolism in real time

Ardenkjaer-Larsen, J.H.

GE Healthcare, Broendby, Denmark, and Department of Electrical Engineering, Technical University of Denmark, Kgs. Lyngby, Denmark

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Despite significant technological advancements the sensitivity of NMR is limited by the low thermal nuclear spin polarization. At a magnetic field strength of 1.5 T (typical imaging field strength) and room temperature, the 1H spins are polarized to only 5 ppm, and a signal improvement of 200,000 is thus theoretically possible. For other nuclei bearing lower magnetic moments (1/4 for 13C and 1/10 for 15N, respectively, compared to 1H), the theoretical enhancement factor is proportionally greater. In addition the sensitivity of these nuclei is further reduced by the low natural abundance of the NMR-active isotope (1.1 % for 13C and 0.36 % for 15N, respectively.

The objective of the work has been to develop a hyperpolarization method that would enable close to unity polarization of molecules in solution. We describe a novel method of hyperpolarization involving Dynamic Nuclear Polarization in the solid state followed by rapid dissolution. We demonstrate that this method is able to preserve the nuclear polarization in the final liquid solution.

This enables a range of in vivo and in vitro applications. Our interest has mainly been to polarize imaging agents enriched with 13C in specific positions with long T1 to study metabolism by MRI (Metabolic MR). The increased signal obtained by hyperpolarization allows the measurement of metabolism of certain selected substances and consequently report on tissue status at the cellular level. This could be of importance for the diagnosis of cancer and cardiovascular disease, as well as other diseases involving changes in the cellular biochemistry. It has been demonstrated that disease progression and response to therapy can be studied by this technique. A particularly interesting compound has been pyruvate. Pyruvate is a key intermediate in energy metabolism. Hyperpolarized [1-13C]pyruvate has been used in patients with prostate cancer, a first test of clinical performance of this technology.

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