Continuous flow dynamic nuclear polarization of water under ambient conditions for *in-vivo* perfusion MRI

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We are developing the use of dynamic nuclear polarization (DNP) via the Overhauser effect to improve contrast for magnetic resonance imaging (MRI), by continuously generating DNP-enhanced water under ambient conditions. While MRI is a powerful and common technique for *in-vivo* studies, it suffers from a well-known, inherent lack of sensitivity and contrast. Many applications exist where it is desired to visualize the flow or transport of water, such as perfusion imaging of the brain, but separating the water of interest from the bulk signal is difficult. Paramagnetic agents are commonly used to enhance contrast, but these agents do not accurately reflect the function and transport of water in the system due to their large size. In addition, contrast agents can have adverse physiological effects.

To overcome these problems, we are developing novel methodologies to use pure water or saline solution in a hyperpolarized state to visualize the transport of the water as distinct from the bulk signal of the system. We use dynamic nuclear polarization via the Overhauser effect to accomplish effective polarization at room temperature in a continuous flow system, and ^{1}H NMR signal enhancements of -40 fold can be obtained. While the overall signal enhancement is less than dissolution DNP systems, which polarize the sample at 1.2K for hours before rapid thawing and use, the enhancement is still sufficient for imaging contrast, even when including T_1 relaxation during the transit time between polarization and use. The benefits of this method are that enhanced water can be continuously generated, and the stable organic radicals required for DNP can be covalently attached to a solid support and filtered from the flowing water [1], preventing the infusion of radical to the system of interest.

Previously we demonstrated this technique in model systems, to show the feasibility of using water hyperpolarized by the Overhauser effect as an imaging contrast agent [2]. An example can be seen in figure 1, where the system was a tube filled with water and 2mm beads, and the hyperpolarized water flowing into the system can be easily distinguished from the bulk water present in the system. Another benefit of DNP at room temperature is that the equipment can be made small and lightweight; we have demonstrated a portable system for DNP at 0.35T in a recent publication [3].

After these initial proof-of-principle experiments, we are now applying our methodology to *in-vivo* imaging studies. Since the optimal fields for DNP using the Overhauser effect are between 0.1 and 0.5T, either a low-field MRI operating at 0.3T (as shown in figure 2) or the fringe field of a standard 1.5 or 3T MRI magnet can be used to produce hyperpolarized water. In this presentation, we will show our progress in developing the equipment for generation and *in-vivo* imaging of hyperpolarized water, and display some initial results using this water for imaging contrast.

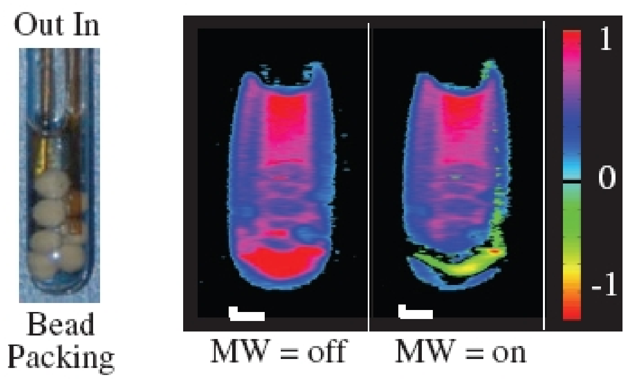

Figure 1: Flow imaging using hyperpolarized water. From left: A photograph of the system, an image without DNP, and an image with DNP. Water enters through the tube on the right and flows out the tube on the left.

Figure 2: A DNP experiment using a clinical 0.3T MRI magnet, using portable NMR and DNP equipment.

References:

1. E.R. McCarney, S. Han, *J. Mag. Res.* 190 (2008) 307-315.
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3. B.D. Armstrong, M.D. Lingwood, et al., *J. Mag. Res*. 191 (2008) 273-281.