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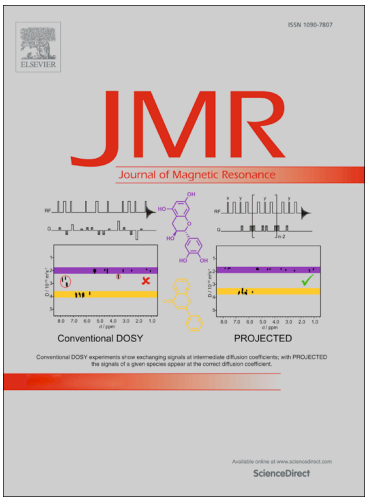

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A Cryogen-Consumption-Free System for Dynamic Nuclear Polarization at 9.4 T

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ABSTRACT

A novel system for dissolution dynamic nuclear polarization based on a cost-effective "cryogen-free" magnet that can generate fields up to 9.4 T with a sample space that can reach temperatures below 1.4 K in a continuous and stable manner. Polarization levels up to $P(^1H) = 60 \pm 5\%$ can be reached with TEMPOL in about 20 min, and $P(^{13}C) = 50 \pm 5\%$ can be achieved using adiabatic cross polarization.

Dissolution dynamic nuclear polarization (D-DNP) has become increasingly popular in nuclear magnetic resonance spectroscopy (NMR) and imaging (MRI) because it can enhance the signals by several orders of magnitude [1]. D-DNP experiments consist of polarizing nuclear spins in samples doped with radicals or other paramagnetic polarizing agents (PAs), placed in a strong magnetic field (typically $3.35 < B_0 < 6.7$ T in most laboratories) at typical temperatures $1.2 < T < 4.2$ K. The electron spin polarization P_e is saturated ($P_e \approx 0$) by microwave irradiation and the DNP effect causes a build-up of the polarization $P(I)$ of protons and other nuclei $I = {}^2H$, ${}^6Li$, ${}^{13}C$, ${}^{15}N$, ${}^{31}P$, etc. The sample is then rapidly dissolved and the nuclear signals are detected in liquid phase in an NMR spectrometer or MRI scanner. The higher the ratio B_0/T, the higher the electron polarization P_e, and, concomitantly, the electron spin relaxation times T_{1e}, often become longer so that a weak microwave irradiation enables to achieve saturation [2]. The line-widths of the proton NMR spectra are determined by dipole-dipole couplings and often exceed 40 kHz regardless of B_0 so that there is no need for expensive high-resolution NMR magnets that can offer a homogeneity $\Delta B_0/B_0 < 1$ ppb (e.g. proton linewidths of 0.4 Hz out of 400 MHz at 9.4 T) but are not suitable to ramp the B_0 field to arbitrary values. For DNP applications, so-called "cryogen-free" or "dry" superconducting magnets that are equipped with built-in helium liquefier and therefore do not require any liquid helium or nitrogen appear more attractive. Such magnets can be ramped to various fields B_0 and their modest homogeneity $\Delta B_0/B_0 < 10$ ppm suffices

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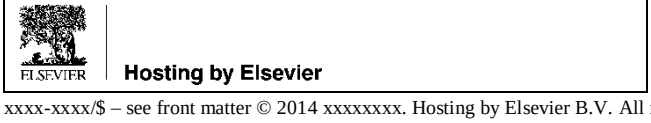

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