



Preparation of Radical-Free Hyperpolarized Water using Photo-induced non-persistent Radicals on a “SpinLab-like” dissolution-DNP Polarizer

Capozzi, Andrea; Coi, Alessandro; Karlsson, Magnus; Lerche, Mathilde Hauge; Ardenkjær-Larsen, Jan Henrik

Publication date:
2017

Document Version
Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

Citation (APA):

Capozzi, A., Coi, A., Karlsson, M., Lerche, M. H., & Ardenkjær-Larsen, J. H. (2017). Preparation of Radical-Free Hyperpolarized Water using Photo-induced non-persistent Radicals on a “SpinLab-like” dissolution-DNP Polarizer. Abstract from 58th Experimental Nuclear Magnetic Resonance Conference, Pacific Grove. , California, United States.

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

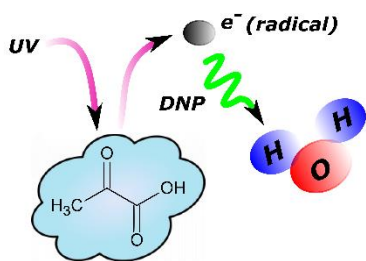
- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Preparation of Radical-Free Hyperpolarized Water using Photo-induced non-persistent Radicals on a “SpinLab-like” dissolution-DNP Polarizer

A. Capozzi¹, A. Coi¹, M. Karlsson¹, M. H. Lerche¹, J.H. Ardenkjær-Larsen¹

¹ Department of Electrical Engineering, Technical University of Denmark, 2800 Kgs. Lyngby, Denmark



The polarization of nuclear spins in radical-doped frozen amorphous solid samples can be enhanced by dynamic nuclear polarization (DNP) at low temperature and moderate magnetic field (usually between 3.35 T and 7 T). The polarization is maintained in a rapid dissolution procedure to obtain liquid-state hyperpolarized (HP) molecules in solution [1,2]. In the biomedical field, dissolution-DNP gained more and more success in the last decade since it represents a promising tool for early cancer diagnosis and real time metabolic studies [3,4]. Although dissolution-DNP can potentially be employed to increase the polarization of any non-zero nuclear spin species, the method has mainly been used to study biological molecules labeled with ¹³C in a position with a long T₁. The electron spins introduced in the sample, which embody the source for the polarization transfer to the nuclei in the solid state, become unwanted at the moment of dissolution and transfer of the HP liquid since they represent the main source of spin relaxation, and thus polarization loss.

A typical example is the short T₁ of water protons (¹H) when a paramagnetic agent is present in the solution.

Nevertheless it has recently been demonstrated that HP water, obtained via dissolution-DNP, can be successfully employed to obtain angiographic and perfusion images with high spatial resolution [5, 6]. These pioneering studies provided a novel contrast agent, free of paramagnetic metal ions such as Gd, and based on water only. However they also clearly established the limitations of the state-of-the-art: even though a polarization of about 70% was measured at 6.7 T and 1.2 K in the solid state, after dissolution, once transferred to the measuring apparatus, only 5% of water proton polarization was left in the liquid state [6]. The main reason of this dramatic polarization's reduction has to be attributed to the time employed in scavenging the radical (the procedure takes about 10 s during which the proton T₁ is still 3 – 4 s) [5].

In the present study we show a novel solution to circumvent this issue by employing non-persistent radicals generated by low-temperature, UV-irradiation of pyruvic acid (PA) aqueous solutions. These radicals, in sufficiently high concentration to perform DNP at cryogenic temperature, suffer from thermal stress above 190 K [7]. Thus, they are annihilated within the dissolution procedure, when the DNP sample temperature increases, leaving a HP solutions naturally free of paramagnetic entities [8, 9].

The DNP sample choice was a compromise between good glassing properties and high radical yield after irradiation: a mixture of PA:H₂O 1:1 (v/v) was used [8, 9]. 50 frozen pellets were made pouring 2.5 μL droplets of the liquid sample into a transparent quartz dewar (Wilmad-LabGlass WG-850-B-Q) filled with liquid nitrogen. The sample was irradiated for 100 s with a high power (20 W/cm²) broad-band UV source (Dymax BlueWave 75). X-band ESR measurements (Bruker EMX) showed a radical concentration of 42±2 mM.

The sample was then transferred to a homebuilt 6.7 T dissolution-DNP polarizer equipped with the GE SPINlab fluid path technology for inserting the sample (see [10] for an extensive description of the system). The original sample vial was replaced by a custom-made PTFE reusable threaded vial to facilitate the loading of the temperature sensitive UV-beads.

DNP was performed at 6.7 T and 1.2 K with microwave irradiation with a nominal output power of 55 mW and at a frequency of 188.025 GHz according to the positive maximum of the ¹H microwave sweep (see Fig. 1A). A maximum proton polarization of 40±4% was measured in the solid state (see Fig. 1B). The dissolution was performed with D₂O at 130°C collecting in a syringe 2 mL of HP final solution. The latter was then injected into a 5 mm NMR tube and transferred to a Varian 400 MHz high resolution NMR spectrometer. The ¹H signal was acquired with 5° pulses every 2 s (see Fig 1C). A water proton T₁ of 30.5±0.5 s was measured confirming the absence of radical in the HP solution.

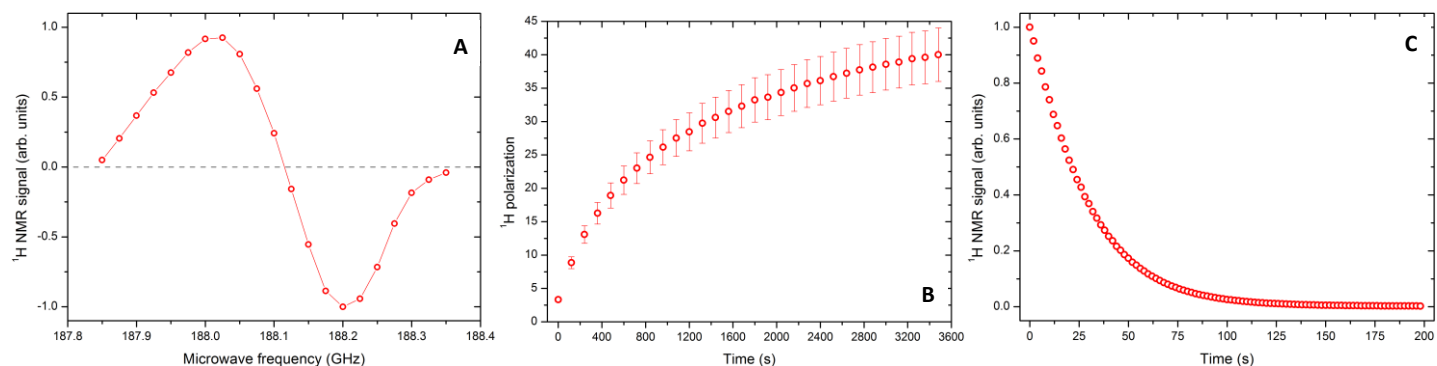


Figure 1. Proton DNP microwave sweep at 6.7 T and 1.2 K (A). Proton DNP buildup measured shining microwaves at a frequency of 188.025 GHz and 55 mW of output power (B). Water's proton relaxation measured at room temperature in a Varian 400 MHz high resolution NMR spectrometer (C).

References

- [1] W. de Boer, J. Low Temp. Phys. **22**, 185-212 (1976); [2] J. H. Ardenkjær-Larsen et al. PNAS **100**, 10158 (2003); [3] A. Comment et al., Biochemistry **53**, 7333 (2014); [4] J. Kurhanewicz et al. Neoplasia **13**, 81 (2011); [5] J. H. Ardenkjær-Larsen et al. MRM **71**, 50 - 56 (2014); [6] K. W. Lipsø et al., MRM, accepted manuscript (2016); [7] M. I. Guzman et al., JPCA, **110**, 3619-26 (2006); [8] T. R. Eichhorn et al. PNAS **110**, 45 (2013); [9] A. Capozzi et al. JPCC, **119**, 39 (2015); [10] R. M. Malinowski et al., JMR, **272**, 141-146 (2016).