Dissolution Dynamic Nuclear Polarization of Non-Self-Glassing Agents: Spectroscopy and Relaxation of Hyperpolarized [1-^{13}C]Acetate

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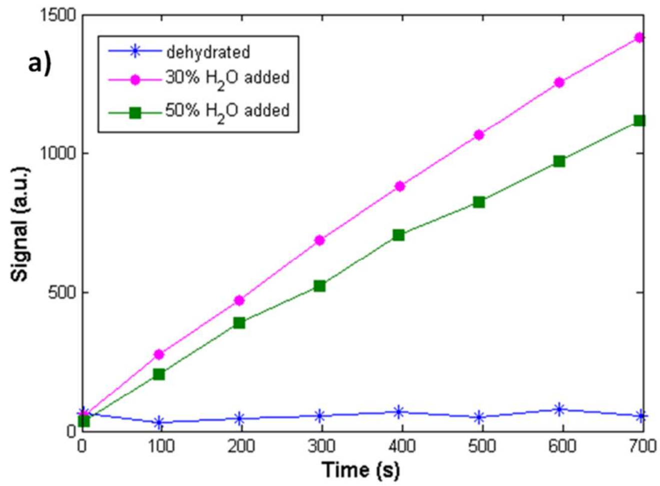
Supporting Information

In these Supporting Information we studied the impact of the glassy matrix on the polarization performance of [1-^{13}C]acetate and in particular, the effect induced by water and glycerol addition. Tris [1-^{13}C]acetate formulation proposed by Jensen and coworkers[1]was used first for the experiments because it had been shown to be effective for *in vivo* studies[2].

As described in the main text, a direct comparison of the polarization enhancement obtained in different conditions was performed by means of the values of normalized plateau value, $\overline{\Pi}$, which is assumed to be proportional to the solid-state polarization, and of build-up time constant, τ, which provides a macroscopic parameter for the evaluation of the polarization dynamics.

1) Water content in the final formulation:

The change in the structural and molecular properties of the mixture induced by hydration was assessed. In Fig. 1a the first part of the build-up curves of the Tris [1-^{13}C]acetate sample are reported after freeze-drying and subsequent addition of H_2O up to 12 μL (50% with respect to the weight of the freeze-dried sample). We observed that the Tris-acetate/OX063 sample deprived of water did not show any polarization, while the progressive addition of water to the mixture, from 30% up to 50% in weight (with respect to the dehydrated sample), contributed reversibly to restore the build-up curve and the polarization enhancement. Moreover, the addition of water in the mixture induced a slowdown of the polarization process (Fig. 1b):we speculate that the “dilution” of the ^{13}C nuclei in the mixture was responsible for the increase of τ through a modification of the spin diffusion component in the polarization process[3-5]. This evidence quantitatively demonstrates the effective role of water in the achievement of an amorphous solid and confirms that the physical dispersion and the glassy properties of the matrix are the first requirement for efficient polarization of the DNP sample.



b)

H_2O added	τ build-up (s)	Π value (a.u.)
8 μL	1518.6	3733
12 μL	2794.9	4293

Figure 1: (a) The zoom of the initial part of the build-up curves of the Tris [1-^{13}C]acetate is reported for the same sample dehydrated and subsequently added of H_2O up to 50% in weight compared to the dehydrated sample; in (b) the τ constant and plateau value ($\overline{\Pi}$) are reported.

2) Glycerol contentin the final formulation:

We evaluated the impact of glycerol on the Tris-acetate formulation as working model. The improvement of the sample homogeneity and stability given by glycerol formulation[6](10% in weight) resulted in an increase in the solid-state polarization ($\overline{\Pi}$) compared to the same formulation without glycerol (Fig.2a), despite the higher dispersion of ^{13}C spins in the sample. On the other hand, τ increased by 15% after glycerol addition(statistically significant, $p<0.05$), probably because of the increased ^{13}C-^{13}C distance and therefore of less efficient spin diffusion[3-5] (Fig.2b), according to the same mechanism previously described for water supplement. These results show the crucial role of glycerol as a glassy agent for dissolution-DNP samples. We anticipate that similar results could be obtained with different molecules, other than Tris [1-^{13}C]acetate.

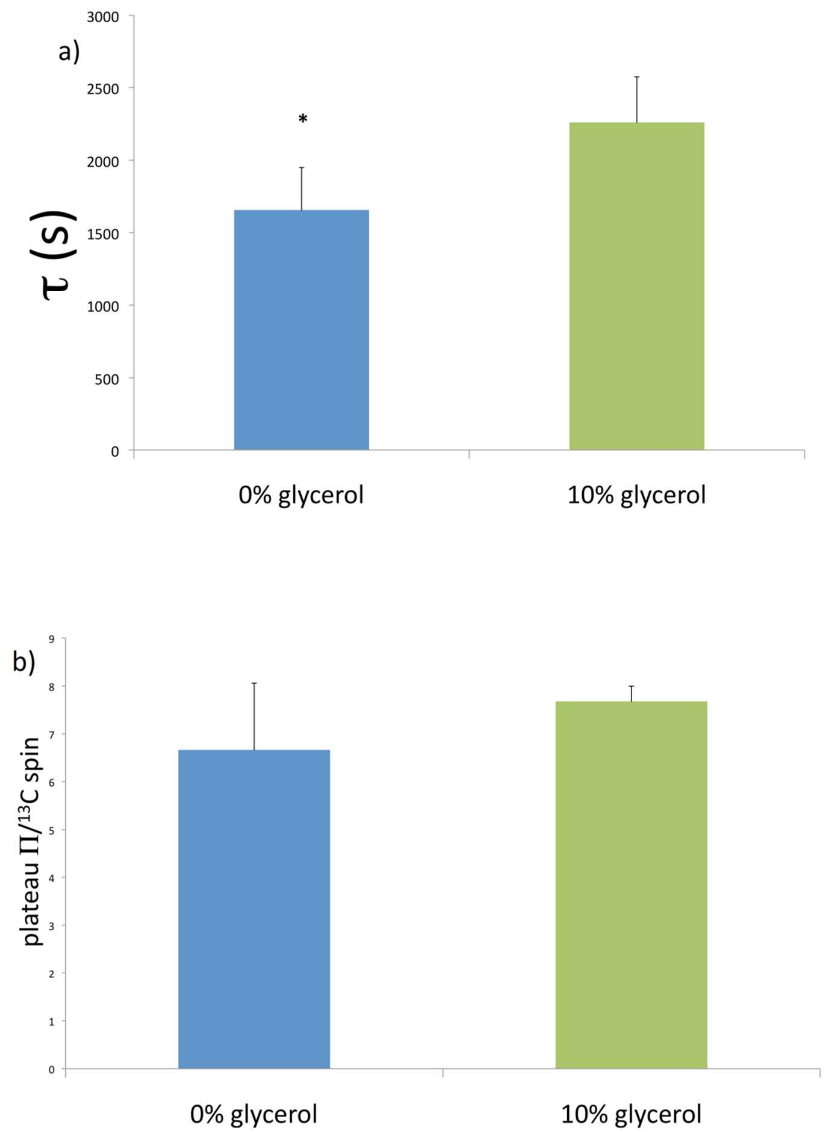


Figure2:Normalized plateau value, $\overline{\Pi}$, and build-up time constant, τ, obtained at 3.35 T/1.4 K for Tris [1-^{13}C]acetate samples without and with addition of 10% *w:w* glycerol to the formulation.

3) Liquid-state polarization data:

The amplitude of the build-up and the thermal signal at the solid state are proportional to the ^{13}C-spins in the sample underwent DNP; nevertheless a partial loss of polarization in the dissolution pathway and in the final step of dilution may occur during dissolution, thus reducing the achievable % of polarization at the liquid-state. Indeed, the step of dissolution could destroy a significant amount of magnetization because of: 1) the rapid change of magnetic field (3.5T →1T tilt step →0T) , 2) the turbulent flow through the fluid path, 3) the timing of recovery and 4) the % of paramagnetic species in the final formulation (i.e. the radical and the metals leached by the bomb circuit during preheating).We report below selected results at different normalized plateau value, for large dose[7,8] dissolution of Na [1-^{13}C]acetate standard formulation (600 μL sample volume, 25 mM OX063 concentration, 7.3 M ^{13}C-acetate). The overall uncertainty of the estimate and the range of variability of the data of liquid-state polarization percentage (%LSP) in respect to the normalized build-up plateau value is indeed confirmed.

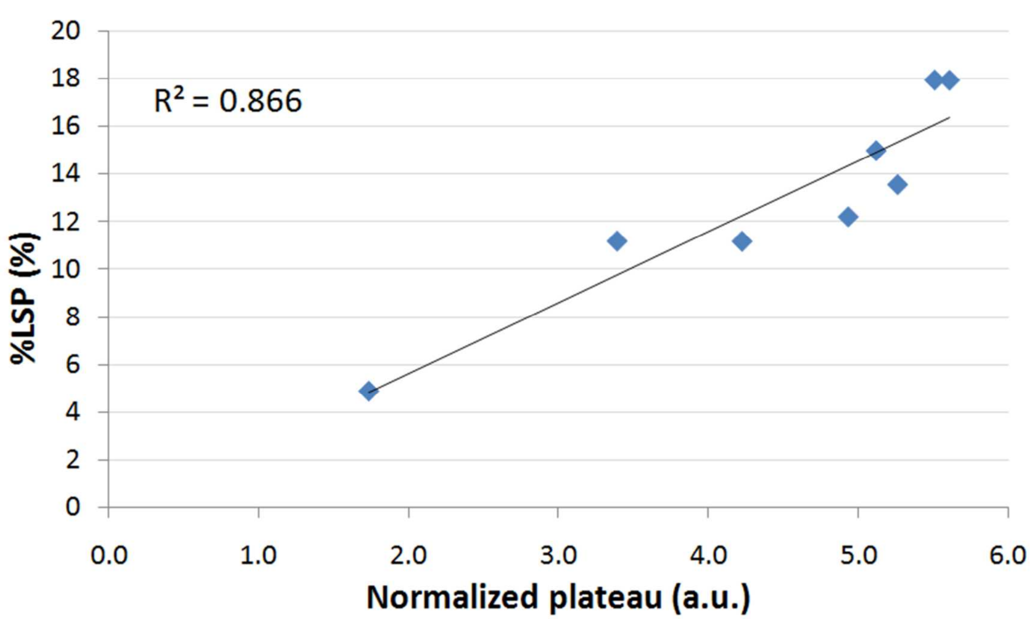


Figure 3: The liquid-state percentage of polarization (%LSP) obtained for Na [1-^{13}C]acetate standard formulation samples (25 mM OX063; 7.3 M ^{13}C-acetate) is shown as a function of the normalized solid-state build-up plateau value($\overline{\Pi}$): a linear dependence can be found for the reported dataset.

References

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