Hyperpolarization of Small Metabolites without Glassing Agent for Dissolution DNP at 5 T and <1.2 K

Lama, B. (UF, Biochemistry and Molecular Biology); Downes, D. (UF, Biochemistry and Molecular Biology); Collins, J. (UF, Biochemistry and Molecular Biology); Long, J. (UF, Biochemistry and Molecular Biology)

Introduction

Dissolution dynamic nuclear polarization is a technique in which electron polarization of persistent organic radicals is transferred to low abundance nuclei, like ^{13}C or ^{15}N, using microwave radiation at very low temperature followed by rapidly dissolving the hyperpolarized substance with hot solvent and injected the solution into a sample or organism for data acquisition via NMR or MRSI.[1, 2] The extent of polarization of the nuclei is dependent upon several factors including the mechanism of polarization transfer, the magnetic field strength, microwave power and frequency, temperature and sample composition.[3]

Experimental

(1-^{13}C)-enriched metabolites (acetate, pyruvate or butyrate) (3.0 M) and 50 mM 4-oxo-TEMPO were dissolved in 300 µL of solvent (D_2O alone or with perdeuterated glassing agent). Samples were frozen in either liquid nitrogen or 2-methylbutane (isopentane) at 130 K, and polarized at <1.2 K for 2 hours in 5 T magnet (AMRIS) with microwave frequency of 140 GHZ with 50 mW power.

Results and Discussion

Solid state and solution state polarization of a series of samples were measured to study the polarization behaviour as a function of cooling bath and glassing agent used to prepare the solid samples. Glassing agents, like ethanol and glycerol, are necessary for the homogeneous distribution of substrate and radical, leading to better polarization, when samples are frozen with liquid nitrogen even though they are toxic to animals. Samples without glassing agents frozen in isopentane show better and faster polarization than the samples frozen in liquid nitrogen with glassing agents (Table 1).

Table I ^{13}C Polarization build up time constants, solid and solution state polarization for different substrate (3.0 M) and 50 mM 4-oxo-TEMPO with different cooling baths

Substrate	Build up constant (s)	Solid state polarization	Solution state polarization
Acetate/D_2O/Liq. N_2	159±20	11±1%	2.8 %
Acetate/D_2O: EtOH-D_6/Liq. N_2	1150±180	26±2 %	6 %
Acetate/D_2O/Isopentane	479±75	28±2 %	6.1 %
Acetate/D_2O: EtOH-D_6/Isopentane	202±20	17±1 %	3.2 %
Pruvate/D_2O: EtOH-D_6/Liq. N_2	1324±100	16±3 %	-
Pyruvate/D_2O/Isopentane	445±70	16±2%	-
Butyrate/D_2O: EtOH-D_6/Liq. N_2	731±100	11±2 %	-
Butyrate/D_2O/Isopentane	472±30	12±3%	-

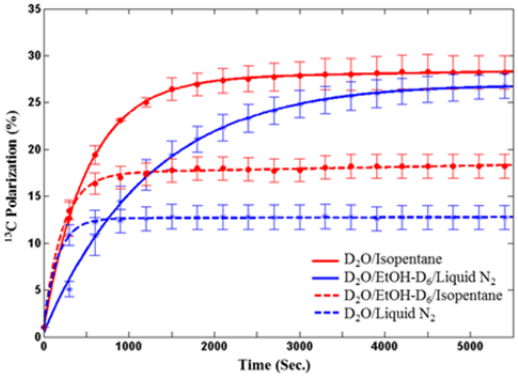

Fig.1 Polarization build up curve for frozen sodium acetate solutions prepared as indicated (replicates, N=3).

Conclusions

Metabolic substrates for dissolution DNP experiments can be polarized without glassing agents. The maximum polarization enhancement is similar to previous reports and the build up time for polarization is faster for samples without glassing agent in comparison to samples with toxic glassing agents.

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References

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