Earth's Field NMR Thermometry

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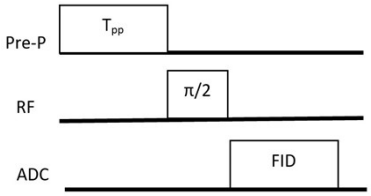
Introduction

- Net equilibrium nuclear magnetization occurs in a sample when placed in a magnetic field
- An RF pulse at the Larmor frequency flips the net magnetization
- T1 characterizes time for magnetization to return to equilibrium
- Earth's Field Nuclear Magnetic Resonance (EFNMR)
  Advantages: Low cost, homogeneous field, accessible
  Disadvantages: Low sensitivity
- *Purpose: Validate T1-based EFNMR thermometry for phantoms with magnetic properties similar to tissue*

Methods

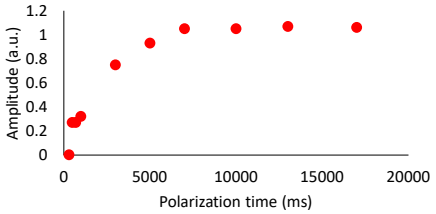
- Samples of 0.25% agarose, 0.5% agarose and pure water were prepared in 500 mL sample bottles and degassed at 90°C
- Samples placed into a circulating water bath to reach thermal equilibrium
- Pulse sequence initiated to measure T1
- Data linearized and T1 calculated from line of best fit
- T1 vs temperature plotted for final results

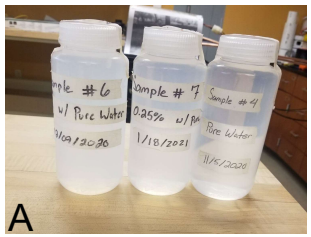


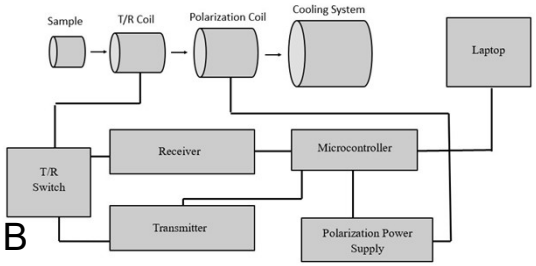
Pulse sequence for pure water sample. T_{pp} is the duration of pre-polarization and π/2 is the RF pulse flip angle. The microcontroller analog-to-digital converter (ADC) records the NMR Free Induction Decay (FID) signal. The signal amplitude (A) is given by:

$$A = A_0\left(1 - e^{-\frac{T_{pp}}{T_1}}\right)$$

Spectrum amp (A) vs. T_{pp} for Pure Water at 25C

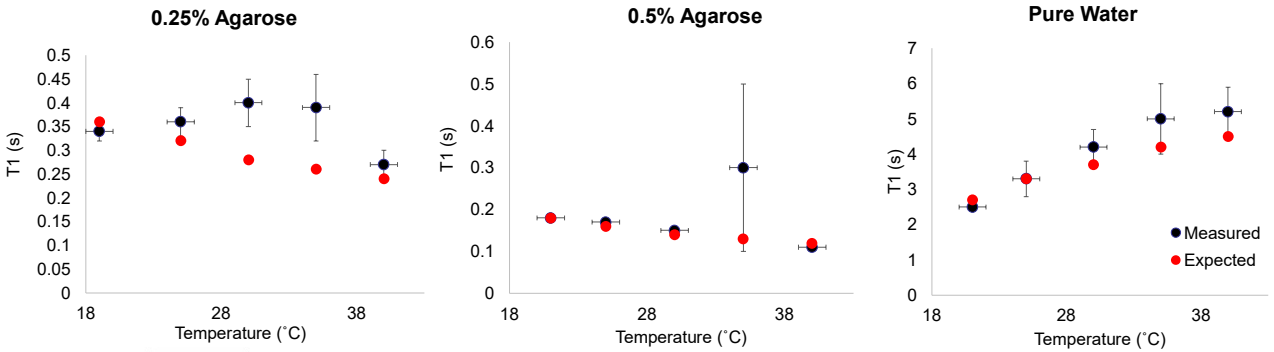


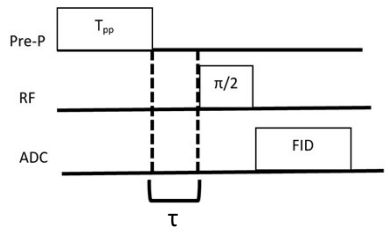




(A) Phantom Samples. (B) Block diagram of homebuilt EFNMR spectrometer. (C) Spectrometer coil assembly. [1]

Results

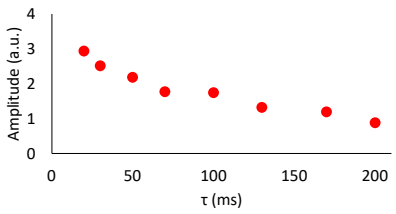




Pulse sequence for agarose samples. T_{pp} is a fixed pre-polarization time, τ is a relaxation delay and π/2 is the RF pulse flip angle. The microcontroller ADC records the NMR signal. The signal amplitude (A) is given by:

$$A = A_0 e^{-\frac{\tau}{T_1}}$$

Spectrum amp (A) vs. τ for 0.5% Agarose sample at 25C



Discussion

- Results for pure water and 0.5% samples are within 1 standard error of the mean of published results [2]
- Results for 0.25% agarose sample are partially in agreement with published results
- Variations in the temperature of the pre-polarization coil and the sample may have affected the measured T1 values
- Future work: Apply method to beef sample to act as a surrogate for human tissue

Acknowledgments

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References

[1] Michal, Carl A. *Meas. Sci Tech.* **21**:105902 (2010).
[2] Vesanen, Panu T., et al. *J. Magn Reson.* ***235***:*50* (2013).