**ABSTRACT**

Fat or water suppression magnetic resonance imaging (MRI) sequences require standards for testing their performance. Lipid/water MRI standards must contain hydrogen chemical shift peaks in the NMR spectrum at approximately 4.5 and 1 ppm. Current standards consist of emulsions of vegetable oil and water, lard and water, purified bovine fat in D₂ chloroform, mayonnaise, or Intralipid. All of these require a preservative, such as sodium azide, and some are subject to phase separation with a temperature change. A mixture of t-butanol and water is proposed as an alternative standard. This system requires no preservative, is not an emulsion and thus is stable over a larger temperature range. We used a Magritek 1T nuclear magnetic resonance (NMR) spectrometer to measure the spin-lattice relaxation time (T₁) of mixtures of t-butanol and water between 0 and 0.9 mole fraction of the 1 ppm spectral component. These T₁ values allow prediction of the MRI image intensity during fat and water suppression imaging sequences.

**OBJECTIVES**

The goal of this project is to use NMR spectroscopy and a phase diagram to show that a simple t-butanol/water mixture can be used as a temperature stable standard for system calibration. Calibration is important because MRI is used to determine diagnosis and prognosis for patients with symptoms of cancer. A better quality image ensures a more accurate diagnosis and a greater chance at an extended, high-quality life for patients.

**NMR BACKGROUND**

MRI instruments in clinical practice utilize the phenomena of nuclear magnetic resonance to create images of a targeted tissue or organ. To create an NMR signal, a magnetic field is applied to the subject being imaged. Due to the spin property of hydrogen atoms and the application of a magnetic field, the atoms are rotated. As the hydrogen atoms relax back to their original state, a current is produced. This results in a potential difference that is plotted against time resulting in a free induction decay (FID) signal. This signal is a decaying sine wave.

**EXPERIMENTAL METHODS**

Ten t-butanol and water mixtures were prepared for collecting T₁ data. The solutions were prepared by mole percentage of CH₃ hydrogens in the mixture. The percentages were: 0, 5, 10, 20, 30, 40, 50, 60, 70, 80 and 90.

A Magritek 1T NMR spectrometer equipped with SpinSolve software was used to record the FID signal from an inversion recovery pulse sequence. The following settings were optimized for each acquisition: number of scans, acquisition time, repetition time, maximum inversion time, and the number of steps. Using MestReNova software, the signal was Fourier transformed to obtain a spectrum of peaks within the sample. Figure 2 is an example of a spectrum from a scan of 30% t-butanol. An inversion recovery pulse sequence was used to collect spectra with 21 different inversion times. The integral over the spectra is obtained and then plotted versus the inversion times selected for the NMR scan. An exponential relaxation curve is fitted to the data plot. The spin-lattice relaxation time (T₁) determined by optimizing this equation to the experimental data.

**RESULTS AND DISCUSSION**

Figure 3 shows the relationship between T₁ and mole % of CH₃ hydrogens for three sets of data. The red, blue, and green markers represent respectively the T₁ values of the combined spectral components, the CH₃ peak, and the water peak. The plot shows a predictable trend in T₁.

A phase diagram of the t-butanol-water mixture was generated from published data to show that the t-butanol water mixture is temperature stable for concentrations between 0 and 90% t-butanol. Phase separation will not occur within this range, even down to 3°C. If the solution should become frozen, thawing and mixing will reform the original mixture.

**CONCLUSIONS**

We believe mixtures of water and t-butanol will make a good lipid-water MRI standard. The combination of these two liquids form completely miscible and stable mixtures at room temperature between 0 and 90 mole % of CH₃ hydrogens. The mixtures are stable down to 3°C. If the solutions should freeze, they only need to be thawed to form the mixture.

**REFERENCES**