Simultaneous Determination of Oxygen Partial Pressure and Temperature of Perfluorohexyloctane with 16.4 Tesla Magnetic Resonance Spectroscopy (MRS)

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Introduction

The purpose of this project was to begin the development of an equation relating the oxygen partial pressure and temperature of perfluorohexyloctane (F6H8) using 16.4 Tesla MRS.

This work is significant in many respects. Specifically, the equation found will be used to test the viability of islet implant grafts. These grafts are being developed in the hopes of becoming a treatment for type 1 diabetes.

Type 1 Diabetes

This is an autoimmune disorder in which a patient's immune system has killed the insulin-producing islets in the pancreas.

Islet cell transplantation has become a method of treating type 1 diabetes, but it is inefficient in practice since many of the transplanted islets die during or shortly after the procedure.

We therefore examine the prospect of islet graft implants to be designed for highest possible viability.

Islet Grafts

For an implanted graft to survive, adequate oxygen must be delivered to the implant site. It is therefore critical to measure oxygen *in vivo*.

MRS provides a non-invasive method of doing this. The purpose of our research is to find a relation between the spin-lattice relaxation rate (R1) measured with MRS and oxygen partial pressure (pO_2) of the site, taking variable temperature into consideration.

Specifically, we wish to be able to ascertain the site's pO_2 and temperature from its R1, measured noninvasively with MRS.

Perfluorocarbons and pO_2

Observing oxygen directly is difficult using MRS, due to the nature of the oxygen molecule. It is efficient to study perfluorocarbons with known oxygen concentrations to find the effect of pO_2 and temperature on R1.

We chose to use perfluorohexyloctane for our research.

Perfluorohexyloctane

The compound F6H8 is a partially fluorinated hydrocarbon with fourteen carbons, six of which are fully substituted with fluorine (see figure 1). The fluorine atoms exhibit local behavior in addition to the global behavior of the overall molecule. Thus, we observe six intensity peaks with MRS. See figure 2 (below) for the intensity spectrum taken.

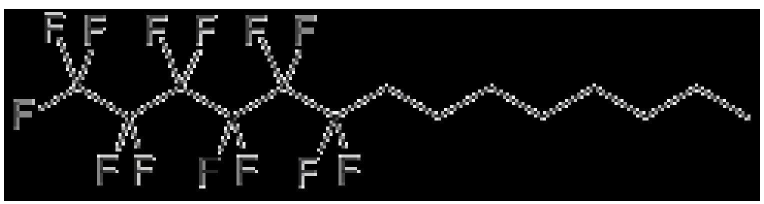


Figure 1: Structure of Perfluorohexyloctane

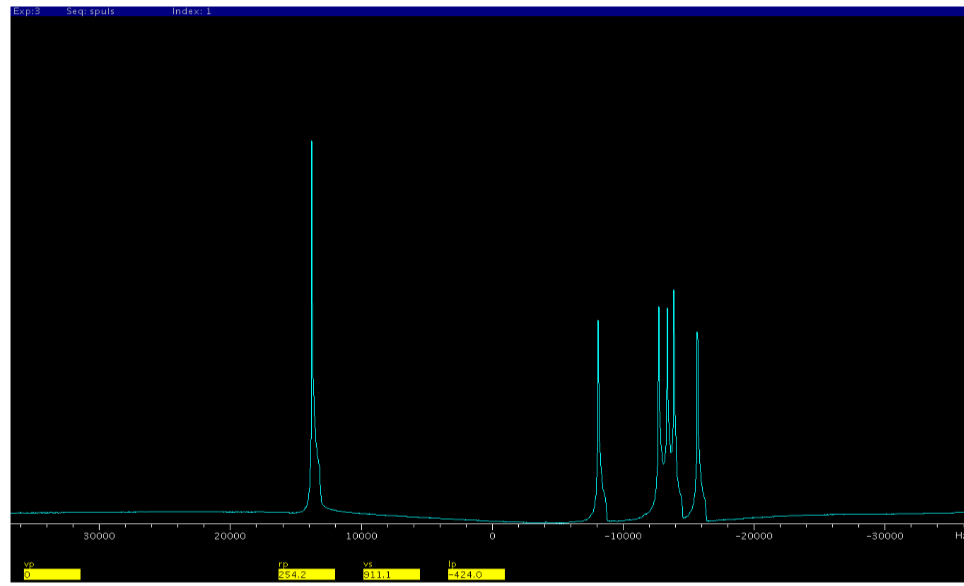


Figure 2: Intensity Spectrum of F6H8 using 16.4 T magnet

Results

We wished to observe both pO_2 and temperature. We began by observing how spin-lattice relaxation time (T1) varied with either variable held constant.

The data produced are shown in figures 3 and 4 (see following two slides). It was found that spin-lattice relaxation rate (R1=1/T1) relates linearly to both parameters within our temperature and oxygen range.

Figure 3: R1vs $pO_2$for F6H8 observed with 16.4 T MRS, temperature held constant at 28.1 C.

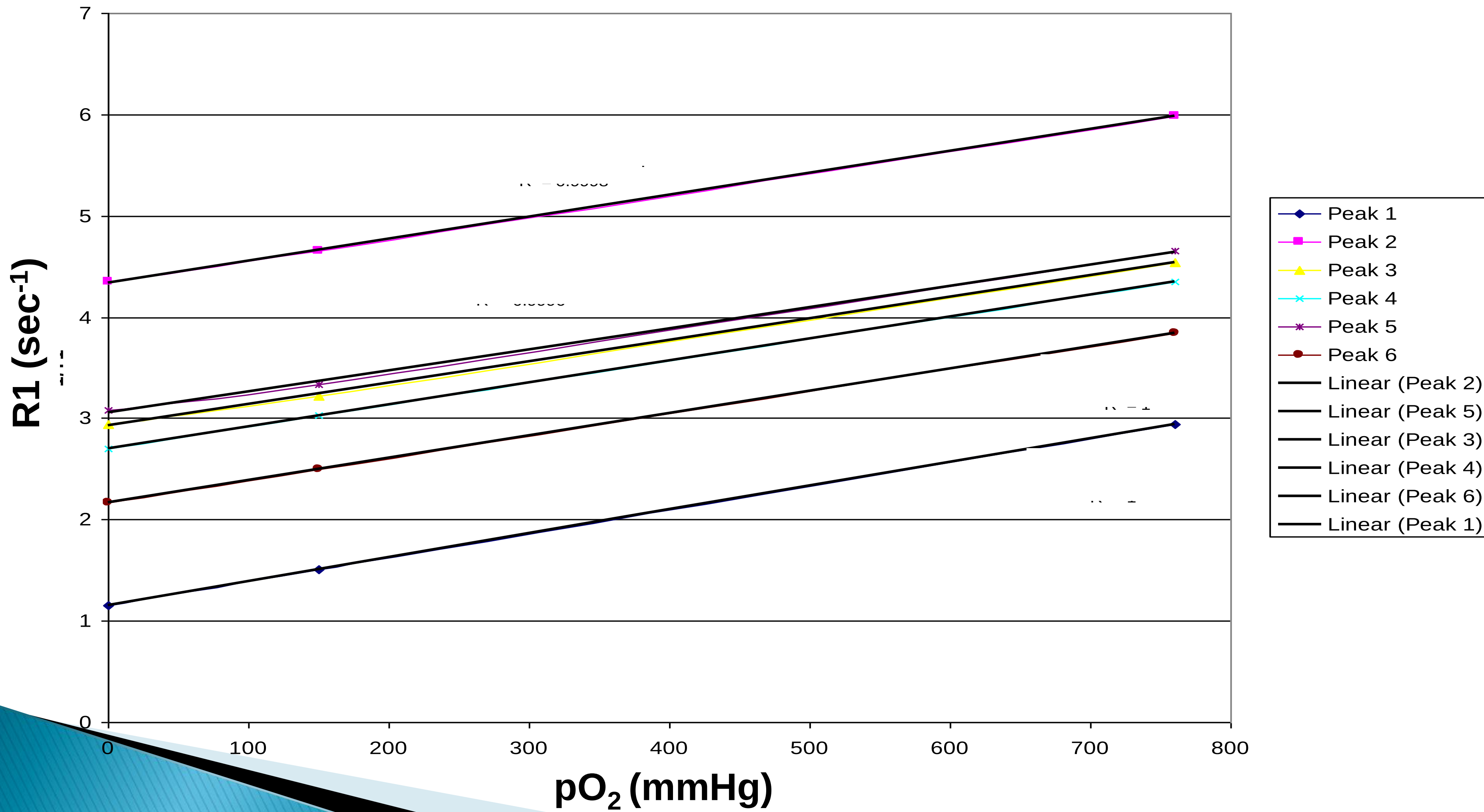
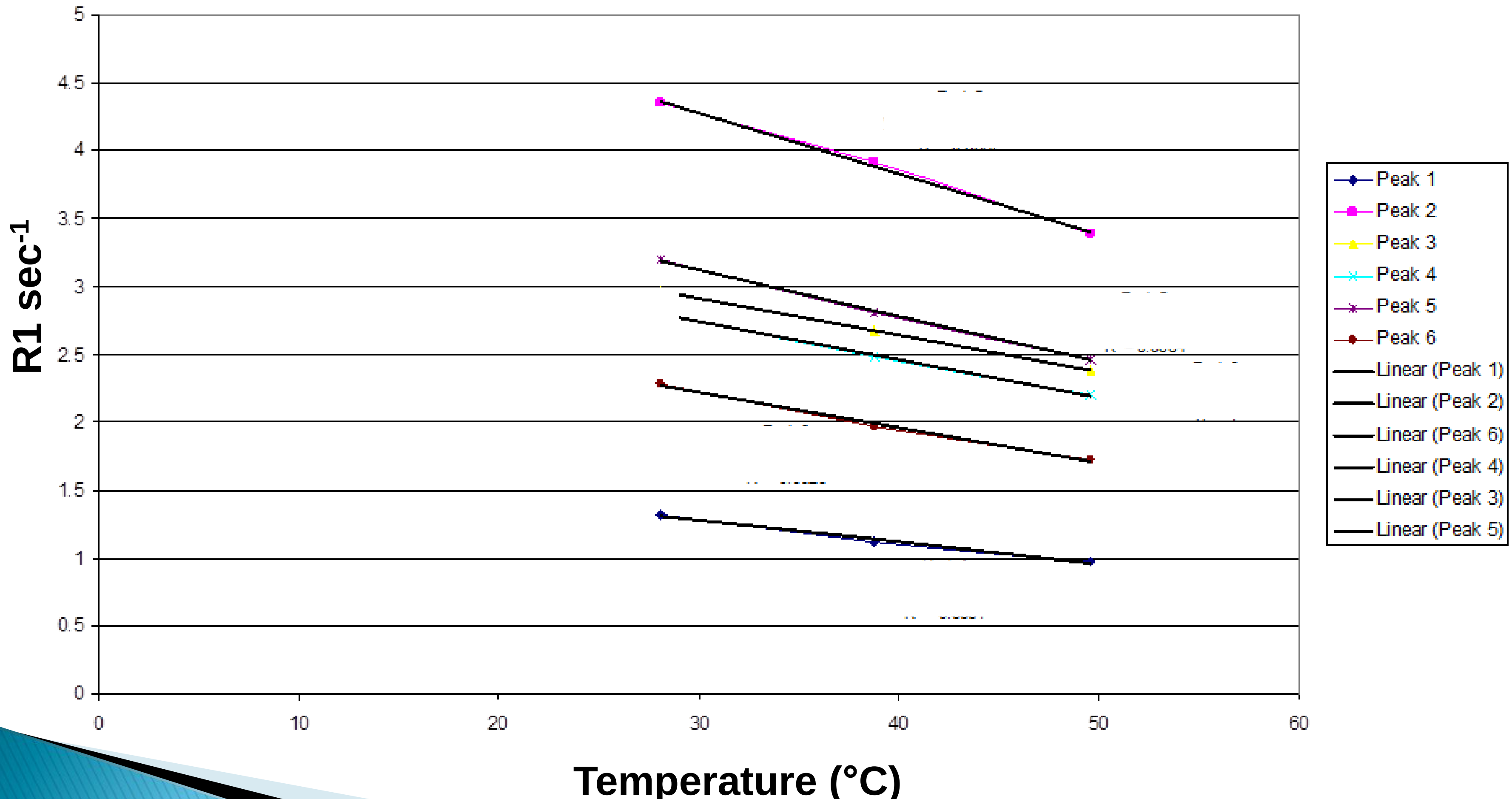


Figure 4: R1vs. Temperature for F6H8 observed with 16.4 T MRS, pO_2 held constant.

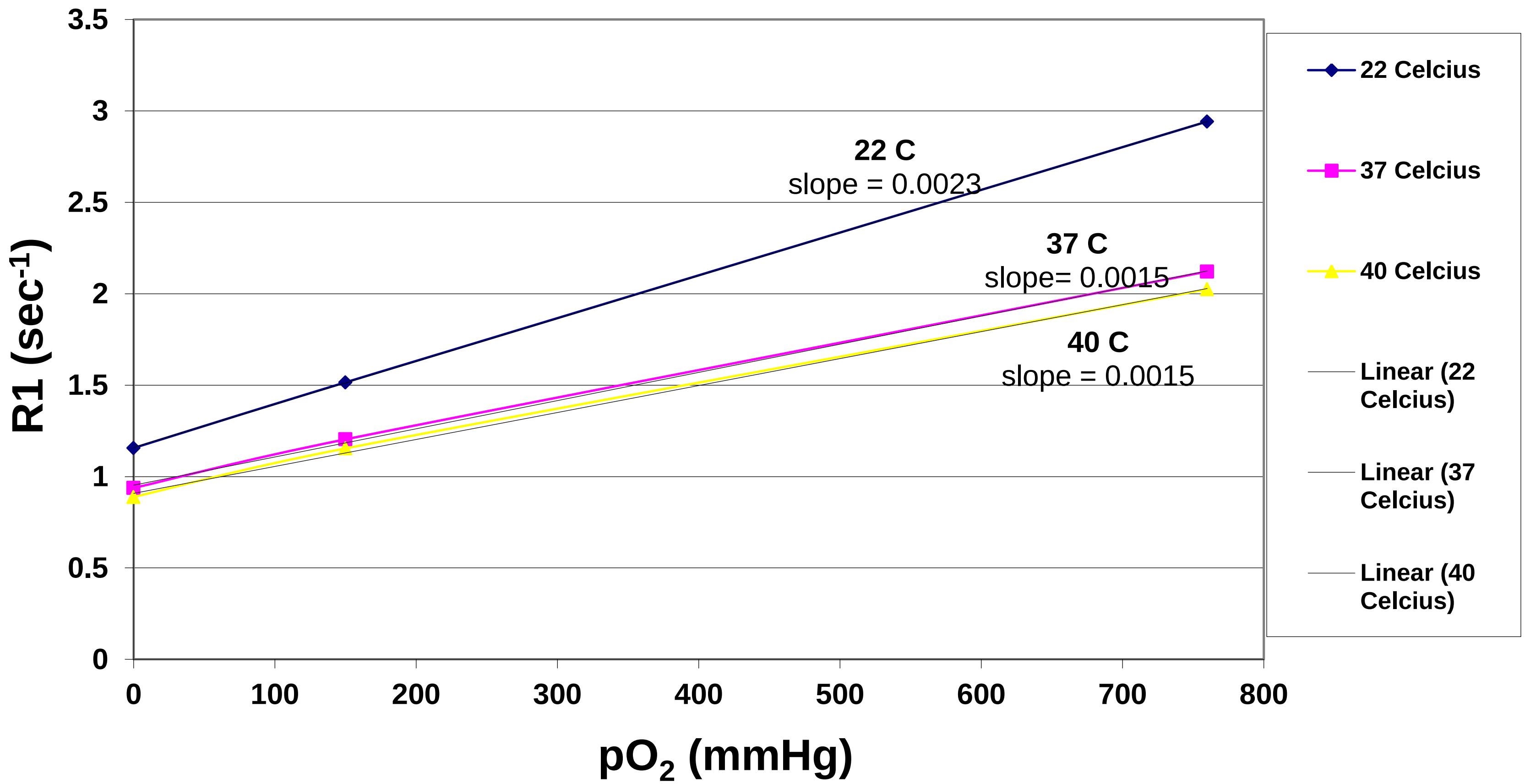


Results: Relation Found

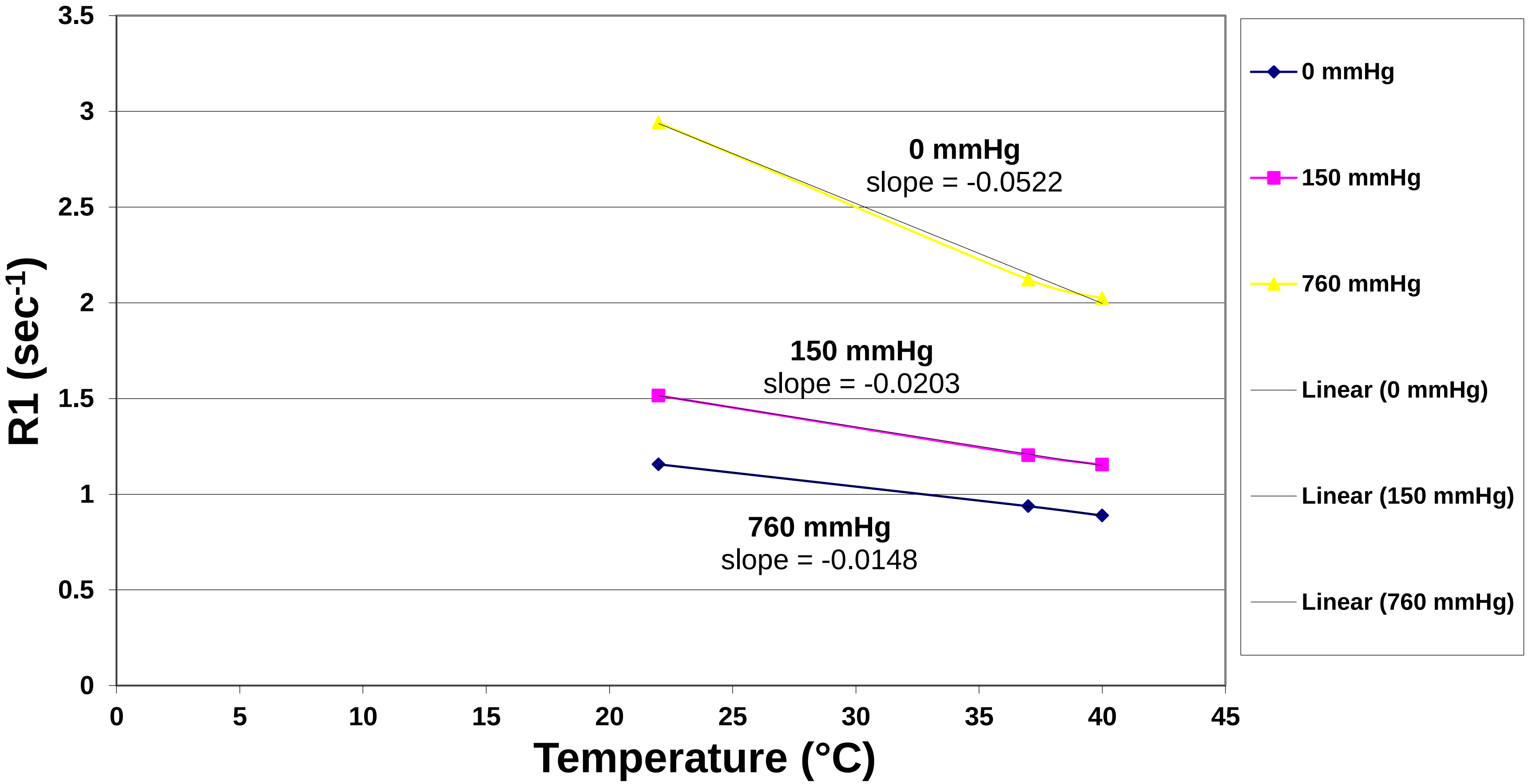
The found relations assumed either temperature or pO_2 was held constant. We wished to see how the oxygen sensitivity of R1(linear slope) changed when the temperature was varied, and vice versa. The results are shown in figures 4 and 5 (see the next two slides).

It was observed that while both slopes do change with the other parameter, the change is small. Particularly in our applications, which will be confined to the body temperature range, the effect is nearly negligible.

Figure 3: R1vs pO_2 with varying temperature for peak 1 of F6H8 observed using 16.4T MRS



R1vs temperature with varying pO_2 for peak 1 of F6H8 observed using 16.4T MRS



Discussion

Six peaks of F6H8 were observed and their relative intensities measured with 16.4T MRS. It was determined that R1 is related linearly to both pO_2 and temperature for all six peaks. It was then found that, while pO_2 sensitivity is temperature dependent and vice versa, the dependence is negligible in our range of interest.

We can therefore construct an equation of the form

$$\mathbf{R1 = A \times (pO_2) + B \times (Temp) + C}$$

Where R1 is the spin-lattice relaxation rate, and A, B, and C are constants.

The development and experimental verification of our equation is the topic of our current work.

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