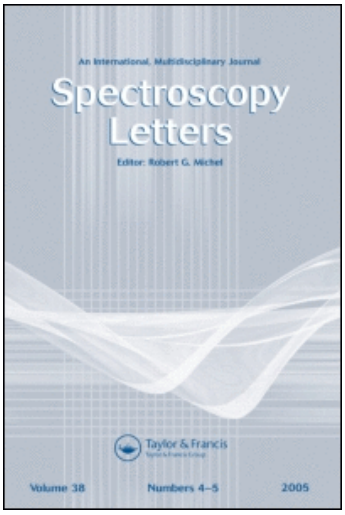

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Concentration Dependence of NMR T1 in Agar Solutions

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CONCENTRATION DEPENDENCE OF NMR T1 IN AGAR SOLUTIONS

Key words: NMR, Spin-Lattice Relaxation Time, T1, agar solutions

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ABSTRACT

In this study, in order to explain solvent proton relaxation mechanism, the spin-lattice relaxation time (T1) of agar solutions was measured as a function of agar concentration. Relaxation measurements were carried out by a FT-NMR spectrometer operating at 60 MHz and inversion recovery pulse squence was used. Relaxation rate(1/T1a) was linearly proportional to concentration of agar solution (C), and the T1 mechanism of solvent water protons in agar solutions should be caused by the chemical exchange of water protons between free and bound water.

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INTRODUCTION

The measured relaxation times of in vivo tissue and quality of MRI images depend upon a series of biological and instrumental factors[1]. Even the instrumental factors alone has necessitated the development of standard calibration materials,which can asses various instrumental errors and image degradation. Agarose gel is becoming an important testing material for such a purpose, and being used as a basic reference material for calibrating relaxation times and imaging parameters [1-4]. Therefore better understanding of relaxation mechanism in agar solutions would be interesting.

To analyse T1 mechanism, this paper reports the dependence of 1/T1 rate on agar concentration.

MATERIAL AND METHODS

The agar gel is obtained when the powder is added to the water, while heating and regularly stirring at the same time. Once cooled at room temperature, the gel is optically transparent and solid; its NMR properties are quite well reproducible and stable in time.

T1 measurements were carried out on a JOEL FX-60Q FT NMR spectrometer operating at 60 MHz for protons. The probe temperature was kept constant at (23±0.5°C) by means of a JNM-VT Automatic Temperature Controller Unit. The inversion recovery pulse sequence was used with pulse spacing τ , being varied from 0.1 to 5,5s, and the infinite τ was 15s [5]. Pulse repetition time PR was set at 20s.

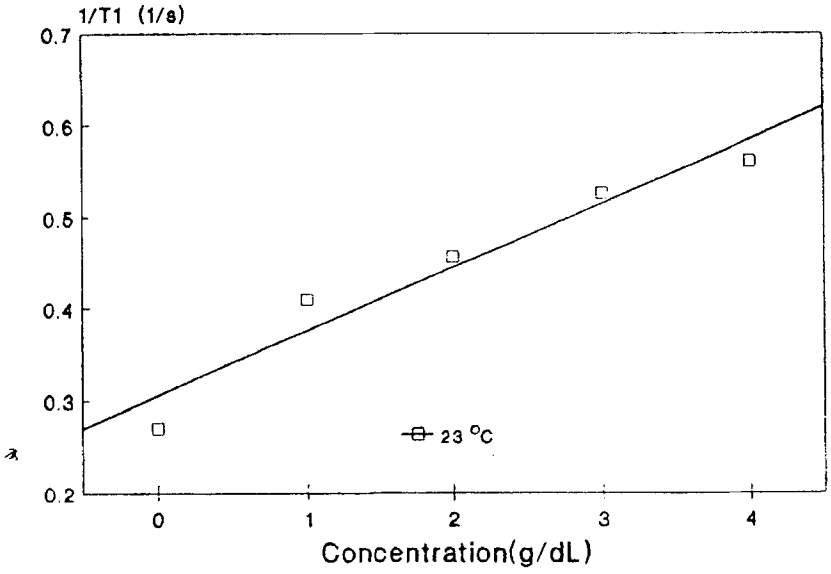

Figure 1. The Least Squares Fitting of 1/T1 in Agar Solutions versus Agar Concentration (g/100mL)

RESULTS AND DISCUSION

Fig.1 shows the dependence of the 1/T1 rate on the agar concentration. The least squares fitting of the 1/T1 versus agar concentration(C) gives a linear relationship (with a correlation of 0.97±0.001) as follows,

$$1/T1a = 0.31 + 0.065\ C \qquad (1)$$

where 0.31 1/s aproximates well the relaxation rate of free water and 0.065 is the slope of the line which measures the relaxation rate change per gram of agar.

In the fast exchange limit, two-site chemical exchange can be expressed as follows[6],

$$1/T1 = Pa/T1a + Pb/T1b \quad (2)$$

where 1/T1 is the relaxation of solution, Pa and Pb are the probabilities for a spin in phase a and b respectively. 1/T1a and 1/T1b are the relaxation times of water protons in phase a and b.

Since Pa = 1-Pb, the Eq.2 can be simplified as

$$1/T1 = 1/T1a + Pb(1/T1b - 1/T1a)$$

In this case, Pb is proportional to the concentration of agar(C), then 1/T1 can be expressed as

$$1/T1 = 1/T1a + KC \quad (3)$$

Where k= Constant x (1/T1b - 1/T1a)

As is seen, Eq.1 is the same as Eq.3. This indicates that the relaxation rate of agar solution is due to fast chemical exchange between free water and water bound to agar, and the contribution of free and bound water are averaged. Relaxation mechanism in tissu water is known to be due to fast chemical exchange between free and bound water [7]. This confirms the choose of agar solution for tissue simulation.

Finally, our data suggest that the relaxation of agar solution is linearly proportional to the concentration of agar, and the T1 mechanism is due to fast chemical exchange of water between bound and free phase.

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