Ultra-low field NMR relaxometry: calibration method and acquisition of T_1-dispersion curves from biological samples extended below 1000 Hz

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Introduction

Fast Field-Cycling (FFC) NMR is a technique used for the investigation of properties of a range of materials. The graph of T_1 versus the magnetic field (known as a T_1-dispersion curve) that is obtained via FFC NMR measurements can be developed into a new diagnostic tool thanks to the information about molecular dynamics which it provides [1].

Methods

FFC measurements were performed using a commercial FFC-NMR relaxometer (Stelar S.r.l., Italy). In order to make measurements at low- and ultra-low magnetic fields, calibration is necessary for the determination and compensation of external stray magnetic fields in the environment, including the Earth's field. This is achieved with the use of correction magnetic fields of varying magnitude and orientation applied during FFC measurements. During this process, the magnetisation precesses around a resultant magnetic field that is composed of the correction and stray magnetic fields, with the frequency of precession determined by its magnitude. As the correction magnetic fields vary, the direction and magnitude of the resultant magnetic field changes, leading to variations in the frequency of precession. The results acquired show the precession frequency from which the magnitude of the stray magnetic field is deduced, for the range of the correction magnetic fields applied. The successful calibration is then verified according to the T_1-dispersion curves obtained from samples of polydimethylsiloxane in the region of μT.

Results

After the successful calibration ultra-low FFC measurements can be performed, as shown from the R_1-dispersion curves of samples of cartilage (Figure 1). The range of minimum measurement frequencies extend down to 400 Hz (corresponding to a magnetic field of *ca*. 9.4 μT).

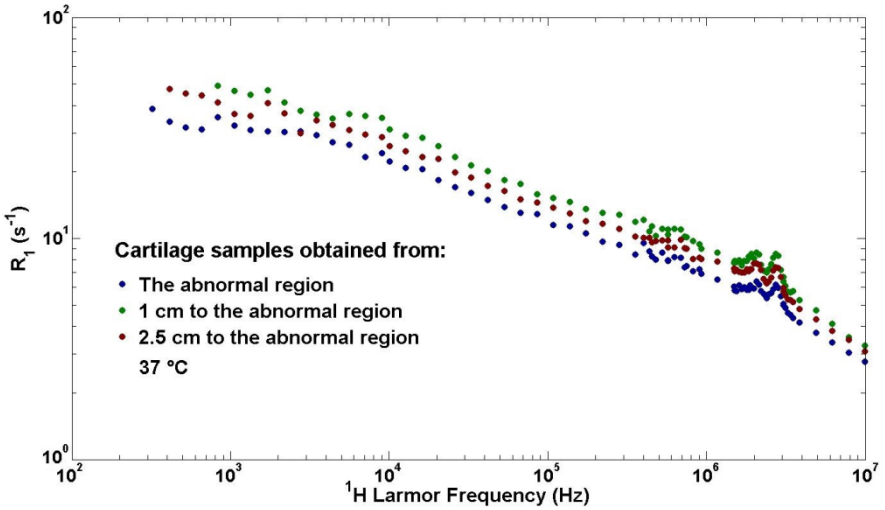

Figure 1. *R_1-dispersion curves of 3 samples of cartilage obtained from the knee of a patient suffering from osteoarthritis, from the abnormal region (blue dots), and distances of 1 cm (green dots) and 2.5 cm (red dots) to the abnormal region respectively. The calibration extends the range of minimum measurement frequencies down to 400 Hz (corresponding to a magnetic field of ca. 9.4 μT).*

Conclusions

This work shows that it is possible to calibrate a FFC NMR relaxometer so that the μT range is accessible for experimentations that are expected to provide clinically relevant information on slow dynamic processes in tissues. Future work will include the translation of this technique to our FFC MRI device as well as a series of clinical experimentation to explore how this portion of the dispersion curve can be exploited in medicine.

References

[1] R. Kimmich, E. Anoardo, *Field-cycling NMR relaxometry,* Progress in Nuclear Magnetic Resonance Spectroscopy, **2004** (44) 257-320.