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The T1-Dispersion Curve as a Biomarker of Colorectal Cancer

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In this study, graphs of T1 relaxation times versus the corresponding magnetic fields, known as T1-dispersion curves, were acquired with Fast Field-Cycling (FFC) NMR relaxometry. These extended to magnetic fields below 17 μT to study the slowest molecular dynamics and to investigate their use as new biomarkers of colorectal cancer.

19 samples of colon were used in total, extracted from 11 patients suffering from colorectal cancer. The samples comprised: matched pairs of normal and cancer tissue samples from eight patients; one normal and two cancer tissue samples from a further three patients. The samples were measured using a commercial FFC NMR relaxometer which applied a Field-Cycling Inversion-Recovery Carr-Purcell-Meiboom-Gill pulse sequence at 37°C. The evolution field varied between 10 MHz to 700 Hz proton Larmor frequency, with the segments below 10 kHz acquired after compensation of the environmental fields. The models applied to fit the acquired curves, presented as R1 (R1=1/T1) versus field, were a sum of power law functions applied to fit the different segments of the background curves, and a sum of Lorentzian functions applied to fit the quadrupole peaks observed between 0.4-0.9 MHz and 1.5-3.5 MHz.

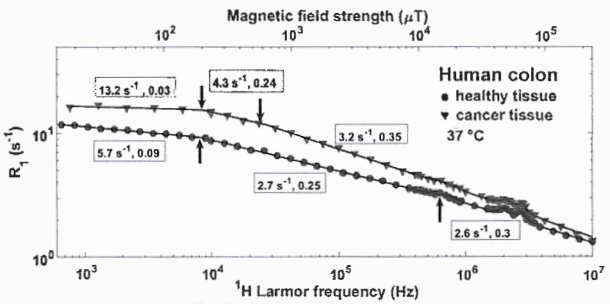

Figure 1. *Example of two R_1-dispersion curves which were acquired from samples of healthy and cancer tissue, extracted from the colon of a patient. The R_1 is plotted versus the applied field, expressed in units of μT and proton Larmor frequency, on logarithmic scales. The arrows illustrate the inflection points of the curves, and the boxes report the vertical level (sec^{-1}) and slope (unit-less) of each segment which were measured via the curve fit parameters (R^2>0.99).*

As seen in Figure 1, the R1-dispersion curves acquired showed three segments of power law distributions with different vertical levels, slopes and lengths, as well as three quadrupole peaks of Lorentzian distribution. Additionally, Figures 2a,b show that there are differences in the average R1 values at fields below 10 MHz, as well as in the average slopes of the segments which lie below 1.2 kHz and between 0.7-1.8 MHz, between the normal and cancer tissues. This work shows that there is an enhanced T1-contrast at ultra-low fields, and that T1-dispersion curves have potential as new biomarkers of colorectal cancer.

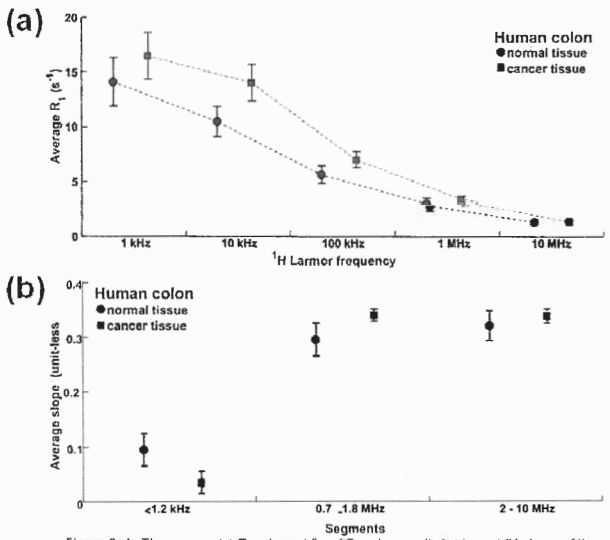

Figure 2a,b. *The average (a) R_1-values at five different magnetic fields, and (b) slopes of three different segments of the R_1-dispersion curves acquired from the normal and cancer tissue samples.*

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