NMR Relaxation Times of Animal Brains and Protein Models: Implications for Human Brain ULF-MRI

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Abstract*— The slow molecular dynamics of proteins reveal important interactions of tissue surfaces such as proton and molecule exchange mechanisms. Clinical magnetic resonance imaging (MRI) machines operating in static fields B_0 of typically several tesla use the so-called $T_{1\rho}$ technique to acquire this information. In the $T_{1\rho}$ method, a radiofrequency (RF) spin-lock field induces an additional rotation of the precessing magnetic moment. This technique, however, may exceed the specific absorption rate (SAR) limit, putting subjects at risk. Ultra-low-field (ULF) MRI, based on Superconducting QUantum Interference Devices (SQUIDs), directly detects slow motions of protons at B_0 of typically 100 μT. Using our ULF MRI system at Berkeley, we systematically measured the T_1 and T_2 dispersion profiles of rotationally immobilized gels of bovine serum albumin (BSA) and *ex vivo* pig brains with variable static fields ranging from 55 to 240 μT. Comparing the ULF results with $T_{1\rho}$ dispersion obtained at 7 T, we find that the degree of protein immobilization determines the frequency-dependence of both T_1 and $T_{1\rho}$. Furthermore, scans of *ex vivo* pig brain showed similar behavior between cross-linked proteins and brain tissue. In addition, a subtle elbow in the ULF T_1 dispersion was observed at ~140 μT, which is tentatively attributed to the local dipolar field of surrounding macromolecules. However, the $T_{1\rho}$ scan removed the elbow because of heating [1]. These results suggest that ULF MRI may be used to image stroke or traumatic brain injury (TBI) with a negligible heating challenge.

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