Signal-to-Noise Ratio Improvement for MR proton spectroscopy at 3T using a ultra High Dielectric Constant (uHDC) Material Sleeve

Sebastian Rupprecht[1], Byeong-Yeul Lee[2], Xiao-Hong Zhu[2], Wei Chen[2], and Qing X Yang[1,3]

[1]Center for NMR Research, Penn State College of Medicine, Department of Radiology, Hershey, PA, United States, [2]Center for Magnetic Resonance Research, Department of Radiology, University of Minnesota, Minneapolis, MN, United States, [3]Center for NMR Research, Penn State College of Medicine, Department of Neurosurgery, Hershey, PA, United States

Target Audience: MRS scientists; RF engineers interested in utilizing ultra-high dielectric constant (uHDC) materials

Introduction: Previously ultra-high dielectric constant (uHDC) materials have been shown to significantly improve B_1^+, B_1^- and SNR while drastically reducing transmit power in proton imaging at 3.0T [1]. Such RF field enhancement is of great value for MRS in human brain as the SNR remains a major limiting factor for its broad clinical applications. In the work, we investigated SNR improvement in 1H MRS with the uHDC pad directly incorporated into a standard head coil at 3T.

Materials and Methods: Human studies were performed on a Siemens Trio 3T using a standard clinical 8-channel receive only head coil. As shown in Figure 1, the lower portion of the subjects' head was surrounded with a sleeve of 5 uHDC blocks (PZT, TRS, State College, PA, USA; permittivity 1 000). To keep the localized spectroscopy voxel the same relative to iso-center, the subjects head was lifted with a thin cushion in the no block case. During the actual experiment each case was shimmed to the same line width. Optimum power was determined via double flip angle method. The single voxel spectroscopy was acquired with the Siemens standard PRESS sequence with FA 90, TE 30 ms, TR 2000 ms for full relaxation 64 averages, and 15 mm isotropic VOI. Both settings are well controlled except tuning and matching. Data was then post-processed on the console and offline using LCModel. Computer modeling was performed with the identical experimental setup using xFDTD (Remcom, State College, PA, USA). The human model Ella from the Virtual Family was used for our computer modeling.

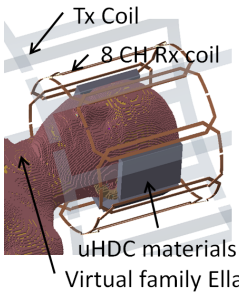

Figure 1 Simulated setup, similar to the in-vivo experiment pursued.

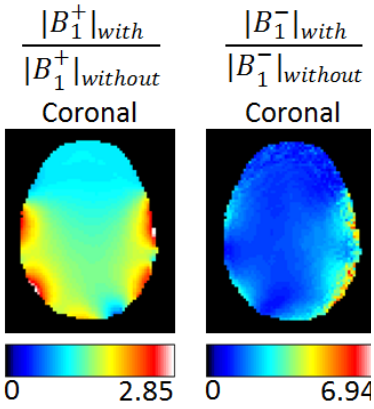

Figure 2 Simulated transmit efficiency and receive sensitivity distributions for the given setup.

Table 1 – Experimental results

	With uHDC	Without uHDC	Change[%]
SNR	26	12	+ 136
Reference voltage	150	242	- 40

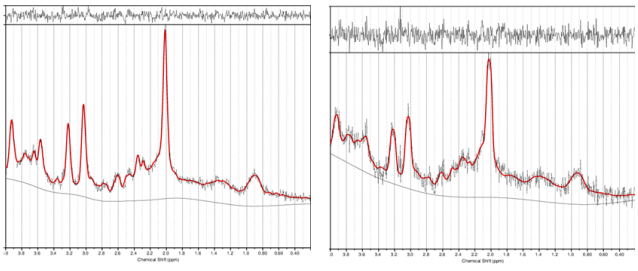

Figure 3 The two resulting spectra from the in-vivo experiment. Left: using uHDC sleeve (LCModel SNR: 26); Right: standard clinical setup (LCModel SNR: 12)

Results and Discussion: The simulation of our experimental set up depicted in Figure 1 shows strong enhancements in both B1+ and B1- utilizing uHDC block as demonstrated in Figure 2. As much as 2-fold B1 improvement can be achieved in the cortical regions near the uHDC block. And 40 to 50 % increase in the center of the brain. The SNR of 1H spectra calculated with LCModel is more than doubled with the uHDC block (12 vs. 26). As indicated in Figure 3, the noise level is visible reduced with uHDC, suggesting a potential denoising effect.

Conclusion: The simple addition of 5 uHDC blocks in a sleeve inside a standard clinical head coil greatly improve the SNR of 1H MR spectra. We anticipate that such improvement could be even greater with optimized configuration as the experimental results presented here were likely obtained under suboptimal conditions.

References: [1] Rupprecht et al., Drastic Enhancement and Manipulation of the RF Field with Ultra High Dielectric Constant (uHDC) Material at 3T, Proceedings ISMRM 2013 p. 5458