EFFECT OF ION SIZE ON CONDUCTIVITY MEASUREMENTS OF MR-PHASE-BASED ELECTRIC PROPERTIES TOMOGRAPHY.

Jan Sedlacik[1], Ulrich Katscher[2], and Jens Fiehler[1]
[1]University Medical Center Hamburg-Eppendorf, Hamburg, Hamburg, Germany, [2]Philips Research Europe, Hamburg, Germany

TARGET AUDIENCE: Researchers interested in new MRI contrast methods.

PURPOSE: MR-based Electric Properties Tomography (EPT) provides a non-invasive means to assess electric tissue properties such as conductivity. It is based on the measurement and post-processing of the complex active component of the RF excitation field (B1) [1]. EPT was shown to depend on ion concentration [1] and temperature [2]. In this study, we report on the effect of ion size on the conductivity measurements of EPT which demonstrates the dependency of EPT on ion mobility.

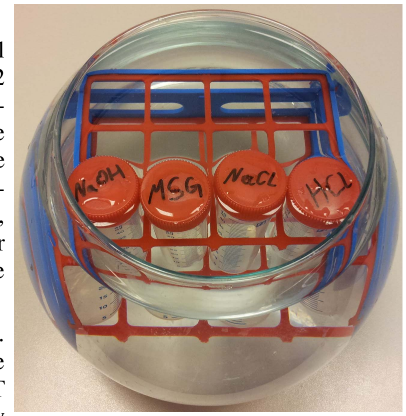

Figure 1: *Photograph of phantom with tubes filled with NaOH, MSG, NaCl and HCl.*

METHODS: A phantom consisting of four 50 mL Falcon tubes placed in the center of a 4.5L glass bowl was measured using 3D balanced FFE sequence (TE/TR = 1.7/3.3 ms, flipangle = 38°, voxel size 1×1×2 mm^3, bandwidth = 836 Hz/pixel, NEX =4) on 3T Ingenia Philips-MRI. Conductivity maps were reconstructed by MR-phase-based EPT post-processing [3] focusing only at the center part of the phantom with the tubes. Conductivity values were measured by averaging over 15 mm 2D circular ROIs in each tube. The bowl as well as one tube were filled with 1 g NaCl per 100 mL H_2O solution to resemble physiological conductivity. 1 g NaCl corresponds to 17.1 mmol which translates to 2.89 g of Monosodium glutamate (MSG, $C_5H_8NO_4Na$) or 17.1 mL of 1 Molar NaOH or HCl per 100 mL solution which were filed into the other tubes. Especially the glutamate ion of the MSG resembles a much larger charge carrier than compared to the other solutions.

RESULTS: Signal magnitude was decreased for MSG due to magnetization transfer effects (Fig. 2, left). Signal phase showed distinct inhomogeneity over the phantom especially in the center which is caused by the B_1 inhomogeneity of the transmit system of the MRI scanner (Fig. 2, right). The applied phase-based EPT assumes constant B1 magnitude, which is not perfectly fulfilled in the given experiment, causing artificially lowered conductivity at the bottom of the EPT map (Fig. 4). The center part, however, could nicely be reconstructed and the following conductivity measurements were obtained: NaOH: 2.98±0.012 S/m, MSG: 0.87±0.016 S/m, NaCl: 1.63±0.018 S/m and HCl: 5.52±0.020 S/m. Plotting the conductivity over the average ionic radius and molecular weight shows an almost linear decrease with respect to the ionic radius, but a steep decrease with respect to the molecular weight especially between HCl and NaOH.

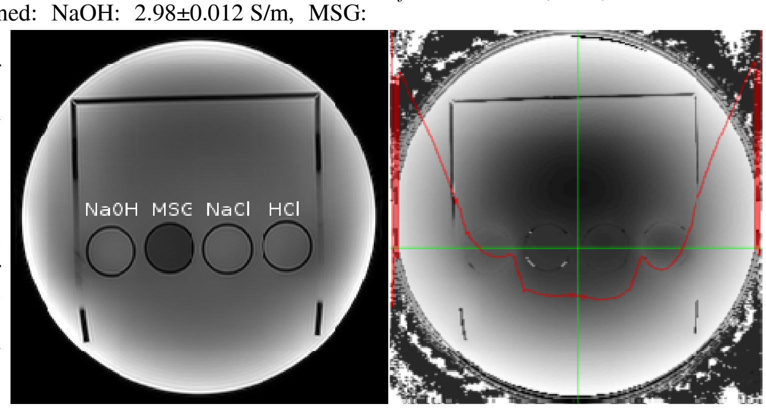

Figure 2: *MRI magnitude (left) and phase images (right). The magnitude of the MSG solution is lowered due to magnetization transfer effects. Conductivity is reflected by the curvature of the phase profile (right, red curve)*

DISCUSSION: The results clearly demonstrated the effect of ion size, and therefore ion mobility, on the EPT conductivity measurements. Due to the much smaller free protons in HCl the conductivity dramatically changes between HCl and NaOH which have similar molecular weights. On the other side, the contribution of the much larger glutamate ion on EPT conductivity is negligible which effectively bisects the amount of EPT-detectable ions resulting in nearly half conductivity of MSG as compared to NaCl.

CONCLUSION: The effect of ion size on EPT could clearly be demonstrated and is caused by the different mobility of ions with different size.

REFERENCES: **[1]** Katscher U, Voigt T, Findeklee C, Vernickel P, Nehrke K, Dössel O. Determination of electric conductivity and local SAR via B1 mapping. IEEE Trans Med Imaging. 2009 Sep;28(9):1365-74. **[2]** Leussler C, Karkowski P and Katscher U. Temperature-dependent Conductivity Change using MR-based Electric Properties Tomography. Proc ISMRM. 2012 (20):3451. **[3]** Voigt T, Katscher U, Doessel O, Quantitative Conductivity and Permittivity Imaging of the Human Brain using Electric Properties Tomography, Magn Reson Med 2011;66:456.

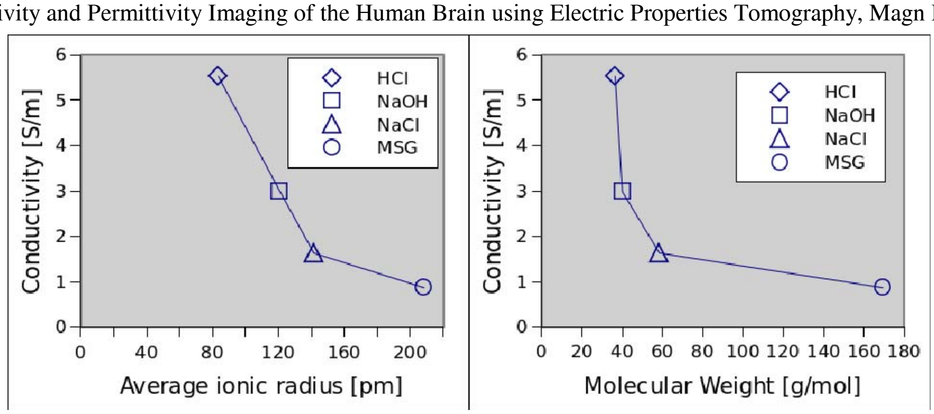

Figure 5: *EPT measurements plotted over ionic radius or molecular weight. Due to the very small size of the free protons in the HCl solution, conductivity steeply increases at lower molecular weight, but increases only linearly with respect to smaller ionic radii. The nearly half conductivity of MSG as compared to NaCl suggests a negligible conductivity contribution of the large glutamate ion effectively bisecting the amount of detectable ions.*

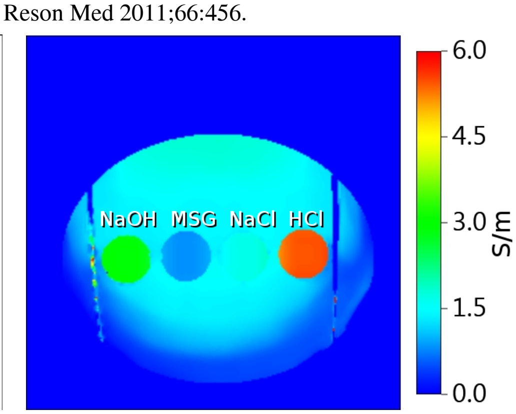

Figure 4: *EPT conductivity map derived from MR-phase focusing on the center phantom region where the tubes were placed. There is no difference in conductivity between tube filled with 1% saline and the bowl filled with the same saline concentration.*