New high dielectric materials for tailoring the B1-distribution at high magnetic field

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Introduction. Sample-induced B1-inhomogeneities at high field are well-documented, and provide significant challenges to accurate MRI quantification. These inhomogeneities arise primarily from the dielectric properties of tissue, which result in partial constructive and destructive RF interactions. However, as shown by Yang et al. [1] external water bags can be used to "direct" the RF field, and to increase the transmit field homogeneity in the head. Here we incorporate materials which have previously been used in high-field dielectric resonators [2,3] to design high-dielectric pads with many desirable MRI properties. These include: (i) a high dielectric constant between 110 and 120 and (ii) a low background signal due to low water content and short T2 and T2* values.

Methods. Calcium titanium oxide (ε_r~150) was mixed with distilled, de-ionized water in different concentrations. The dielectric constants and loss tangents were measured as a function of frequency between 100 and 400 MHz using a dielectric probe kit (Agilent 85070E) and S11 measurements on a network analyzer: results are shown in Figure 1. All MRI experiments were performed on a Philips Achieva whole body 7T system.

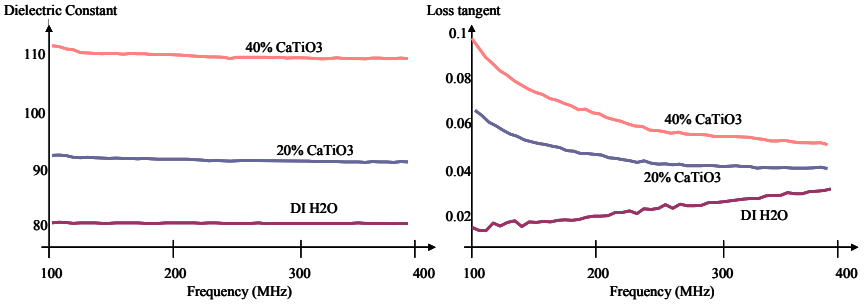

Figure 1. (left) Dielectric constant, and (right) loss tangent of different ratios of calcium titanium oxide and de-ionized water as a function of frequency.

Results. Figures 2(a) and (b) show an axial image through the head of a volunteer at 7 tesla with a 15 x 15 x 2 cm bag of 40% v/v calcium titanium oxide/H_20 placed on one side of the head. The increased signal intensity is particularly pronounced at the base of the brain. Figure 2(c) shows the very low background signal intensity from the high-dielectric material using a long TE gradient-echo sequence [4], used particularly in our laboratory for the measurement of diffuse iron deposits in neurodegenerative diseases. The T_1 value was measured to be 120 ms, and the T_2 12 ms.

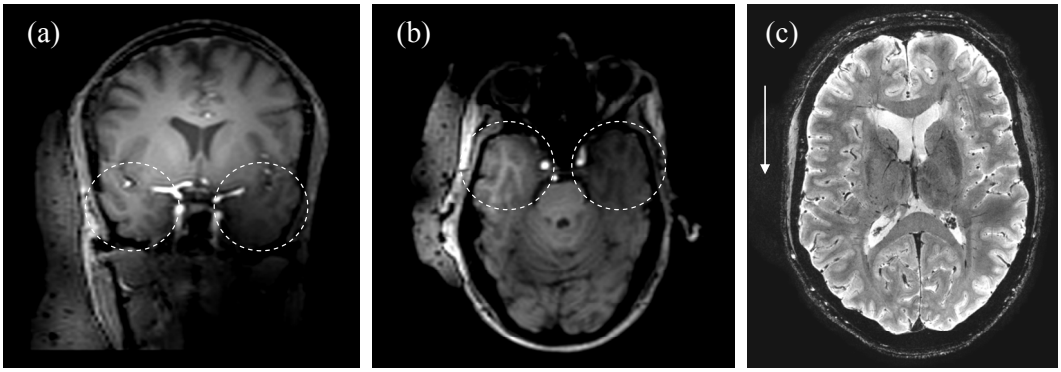

Figure 2. (a) Coronal and (b) axial low-resolution gradient-echo scans with the dielectric material on one side of the head, TR/TE/FA 4.6/2.2 ms/5°, 1.5 x 1.5 x 2 mm.Targeted areas within the white circles show significant increases (>70%) in S/N (c) High resolution susceptibility weighted scan, showing the signal from the dielectric bag (arrow) at noise level. TR/TE/FA 750/25 ms/45°, 0.2 5x 0.25 x 1 mm, 22 slices.

Discussion. A new high-dielectric material using calcium titanium oxide allows tailoring of the RF field at high field. In the head, the high dielectric constant is particularly effective at improving image quality in areas, such as the temporal lobe, usually associated with low signal intensity. In addition to the high dielectric constant, the new material has a very low background signal intensity, without the need for paramagnetic doping.

References. [1] Q.Yang et al., J.Magn.Reson.Imag., 24, 197, 2006. [2] T.Neuberger et al. Conc.Magn.Reson., 33B, 109, 2008. [3] K.Haines et al. J.Magn.Reson., 200, 349, 2009. [4] T.Q.Li et al. Neuroimage, 32, 1032, 2006.