New barium titanate based dielectric materials for high field imaging

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Introduction. The use of suspensions of high dielectric materials to improve brain imaging and spectroscopy at 7 T has recently been described [1,2]. Calcium titanates suspensions can be produced up to a 40% v/v ratio in protonated or deuterated water with an ε_r~110. For certain applications, higher values of ε_r would be desirable. Here we use barium titanates to reach values of higher than 200. One disadvantage of barium titanate is that it cannot reach a high v/v ratio: however,the use of chemical dispersants can increase this to give ε_r values higher than 300. Images acquired at 7 T show significantly increased transmit field strength close to the dielectric material.

Methods. Barium titanate suspensions of different concentrations were prepared, and the dielectric constant was measured using dielectric probe kit and S11 measurements. Darvan 821-A (ammonium polyacrylate) was used as a chemical dispersing to increase the maximum v/v ratio. A pad (15 x 10 cm) containing a suspension of ~25% v/v barium titanate in water was prepared and sealed, and placed behind the head of a volunteer. T1-weighted scans and three dimensional B1+ maps were acquired to determine the effect of the dielectric material.

Results. Figure 1 shows that the maximum v/v ratio of barium titanate in water without dispersant is ~25% giving and εr~180. With the addition of Darvan the εr can reach 300, accompanied by a slight increase in loss tangent.

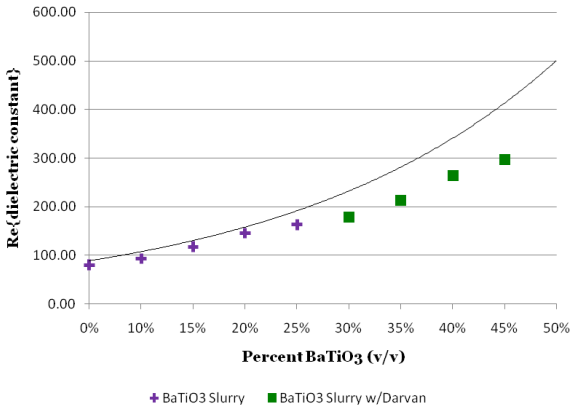

Figure 1. Plot of the real part of the dielectric constant of a barium titanate suspension in water (+) as a function of volume fraction. Adding Darvan (□) allows higher values to be reached. The solid line represents Lichtenecker's logarithmic power law.

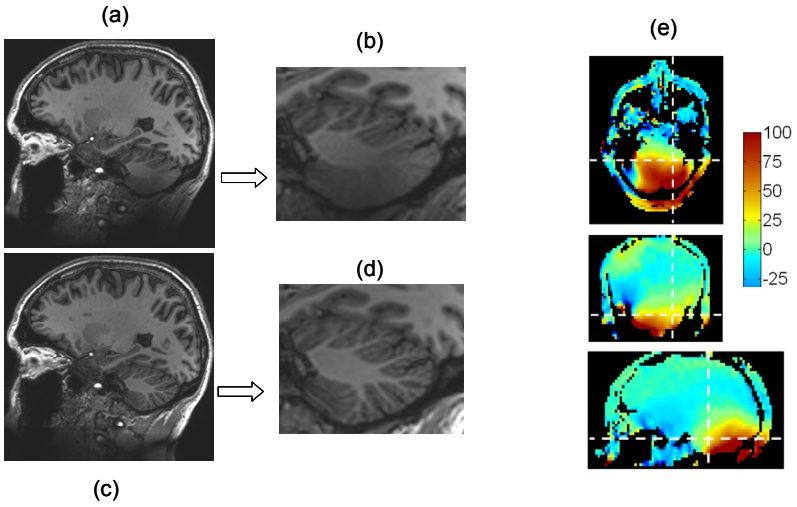

Figure 2. (a) Sagittal T1-weighted image with no dielectric pads, (b) expansion of cerebellar region. (c) Corresponding image with barium titanate pad in place, and (d) expanded region showing much increased tissue contrast and signal-to-noise. (e) Measured percentage change in the B1+ field in all three directions.

Discussion. This work shows the first characterization and application of materials with dielectric constants significantly above 200 to human studies. Strong increases in local B-fields can be induced, which can be used to counteract the intrinsic loss of transmit efficiency in certain areas of the brain at high field. This increase in local signal is accompanied by a slight decrease in global signal throughout the rest of the brain.

References. [1] K.Haines, N.B.Smith and A.G.Webb, J.Magn.Reson., 203, 323, 2010. [2] J.M.Snaar et al. NMR in Biomedicine, in press, 2010.