In vivo High Resolution Sodium MR Imaging of Mouse Brain at 21.1 T

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Introduction
High magnetic fields are expanding our capability to observe and investigate biomedical processes using nuclei beyond proton. The increased sensitivity and resolution are especially valuable for many time limited in vivo studies. The world-record high magnetic field of 21 T (bore 105 mm) built at the National High Magnetic Field Lab (NHMFL) generates new opportunities for non-proton MR imaging. The first sodium in vivo images of a mouse brain were acquired at UWB900 and are presented here. The NHMFL is a user facility and its distinctive imaging capabilities are available for users’ advanced projects nationwide.

Experimental
The MR imaging experiments were performed at sodium frequency of 238 MHz using UWB 900 magnet, Bruker Avance console and PV4.0 / TopSpin 1.5 software. The imaging gradient coil set (Bruker Micro 2.5) has a 40 mm internal diameter and gradients of up to 1.5 T/m provided by Bruker gradient amplifiers (GREAT 60). The unique high field sodium MR imaging capabilities were achieved as a result of multiple steps including the creation of a special probe and experimental setting. The internal diameter of the RF coil (Alderman-Grant design) was 17.5 mm and 25 mm in length. The in vivo probe had a water heated blanket to help animals maintain their body temperature, as well as, a pressure sensitive pad to monitor the animal’s breathing rate while inside the magnet during MR experiments. Animals for MR imaging were anesthetized using an isoflurane/oxygen mixture. All animal experiments were conducted in accordance with the protocol approved by FSU ACUC.

Results and Discussion
Sodium MRI was performed using a custom-designed 3D back-projection pulse sequence with the following parameters: TE = 1.5 ms, matrix = 64x64x64, FOV = 32 mm, SW = 20 kHz, TR = 50 ms, NA = 16. Image processing was performed using Matlab 7.5 and Analyze 7.0 software. The unique resolution for sodium MR imaging of 0.5x0.5x0.5 mm was achieved at a total acquisition time of 55 min (Fig.1). As seen on the image, the sodium signal is high throughout the brain with some noticeable increase of intensity at the edges of the brain (Fig. 2). High resolution in vivo sodium MR imaging is an important tool for many future MRI studies.

Fig. 1. Sodium 3D MR image of a mouse head, resolution is 0.125 µL.

Fig. 2. Profile of sodium MR intensity through a mouse head. High intensity of Na signal at the cortex areas is clearly noticeable.

Conclusions
The first in vivo mice sodium MR images demonstrate a unique sensitivity and resolution of the new high field MRI scanner for non proton MR imaging. The novel in vivo MR imaging capabilities create new opportunities for users to conduct biomedical research using nuclei beyond proton.

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