Multi-Substance RACETE Imaging using k-Space Dependent Phase Offsets

J Balling[1], SM Mayer[1,2], T Schell[1], PM Jakob[1], FT Gutjahr[1]

[1] *University Würzburg, Experimental Physics 5, Würzburg, Bavaria, Germany*

[2]*Leibniz Institute of Plant Genetics and Crop Plant Research (IPK), Seeland Gatersleben, Saxony-Anhalt, Germany.*

INTRODUCTION:

In 2018, RACETE[1] (Refocused Acquisition of Chemical Exchange Transferred Excitations) was demonstrated as a novel approach to visualize chemical exchange with a positive contrast. RACETE exploits the stimulated echo pathway to transfer excitation. Due to this pathway the phase of the preparation is retained in the resulting stimulated echo.

Using this phase information, approaches known from conventional MRI can be applied to chemical exchange imaging. In [1] the phase information was used to separate two simultaneously excited pools by a two-point Dixon-like approach[2] where images with in-phase and out-of-phase excitation were acquired and pools were separated using the sum or difference. In this work we demonstrate another phase-dependent method for multi substance RACETE imaging similar to the Phase offset Multi Planar (POMP) method[3], which allows phase-based separation of parallelly excited multi-slice images.

In RACETE a stimulated echo is repeatedly prepared in a chemically shifted pool by the excitation transfer module (ETM), leading to an accumulation of prepared magnetization in the water pool, which is subsequently read out using a pulse on the water frequency. In [1] a dual ETM RACETE approach was shown to be able to excite two different pools using two sets of selective pulses. This enables the free choice of phase for each of the pools' excitation.

In POMP, multiple slices are excited simultaneously. Using the Fourier shift theorem and varying phases for the slices, slices can be shifted within the FOV for separation. In this work we use the same idea to simultaneously excite two pools with different phases in dependence on the phase position in k-space. This enables the separation of both pools in the resulting image.

METHODS:

All imaging was conducted on a 17.5 T MRI system (Bruker, Ettlingen Germany) using a 20 mm diameter volume birdcage. For direct excitation RACETE images with a FOV of 2 cm x 1 cm (read x phase) and a resolution of 128 x 64 were acquired. For the POMP-like method, the dual ETM-RACETE method was modified to alternate the excitation phase of one of the excited pools by 180° for each k-space phase step resulting in a ½ FOV shift of one of the pools. By doubling the FOV aliasing was prevented. For the measurements shown, the phase resolution was also doubled to retain the same in-plane resolution.

As a phantom, two 5 mm vials were used. On of the vials was filled with salicylic acid (50 mmol) and an additional 3 mm vial was inset (see Fig. 1a). This inset was filled with a Iomeprol solution (83 mmol). The other 5 mm vial contained a mixture of both substances (75:25, Salicylic:Iomeprol).

RESULTS / DISCUSSION:

In Fig 1d the separation using the POMP-like approach is shown. The pools can be separated with a comparable quality as in separate single excitation experiments (Fig 1b/c) and the Dixon-like (Fig 1e - 1h) approach.

In comparison to measuring only one substance at a time the SNR is increased, as the whole measurement time can be used for both substances, in both the POMP-like and the Dixon-like approach. In principle the POMP-like method can be easily extended to an arbitrary number of pools, whereas the Dixon-like approach requires more sophisticated encoding schemes, such as hadamard encoding, affording less flexibility. The technique works equally well with multiband pulses (not shown here).

CONCLUSION:

The preservation of the phase in the RACETE sequence allows the use of several approaches known from conventional MRI. Here the POMP method was transferred to separate two simultaneously excited pools by spatially shifting one of the pools in image space.

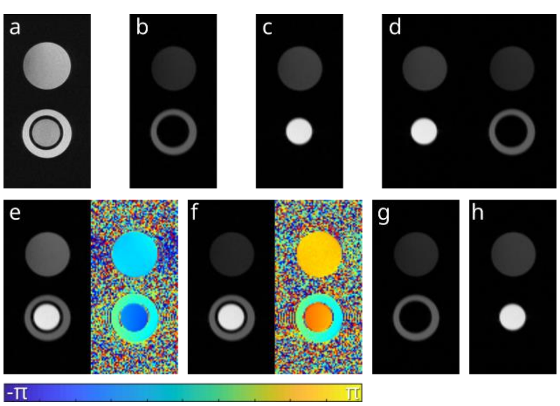

Figure 1

a) 1H-Image **b)/c)** single excitation 9.1ppm/4.3ppm
d) POMP-like **e)/f)** multi excitation phase 0,0/0,π
g) sum of images e,f **h)** difference of images e,f

REFERENCES:

1. Gutjahr FT, et al. Z Med Phys. 2019; 10.1016/j.zemedi.2018.05.005
2. Dixon WT, Radiology 1984; 10.1148/radiology.153.1.6089263
3. Glover GH, J Magn Reson Imaging 1991; 10.1002/jmri.1880010410