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Fast MRI for Spatially Resolved Quantitative Information on Molecular Exchange

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Diffusion EXchange Spectroscopy (DEXSY) [1] is a well established approach to study molecular exchange. It is based on two consecutive pulsed-field-gradient spin echo (PGSE) experiments, which are separated by the mixing time. The effects of molecular exchange can be analyzed my means of the 2D correlation plot obtained through the inverse Laplace transformation. However, it has been shown that the exchange time can be measured by a much faster novel technique called Filter EXchange SpectroscopY (FEXSY) [2], which is a modification of the DEXSY technique. FEXSY is particularly advantageous in cases where two distinct diffusion components can be observed, e.g. due to intra and extra-cellular compartments. In the FEXSY approach the first PGSE experiment is used as a kind of filter, which is designed to selectively reduce the magnetization of the fast diffusing component without affecting the slow diffusing component. The perturbed fraction of the fast diffusing component is detected by the second PGSE experiment after the mixing period. When the mixing period is varied, the fast diffusing fraction is observed to approach the equilibrium value. The analysis of the experiment is based on the Kärger model [3] and yields the molecular exchange time. The reduced experimental time makes the technique particularly valuable to study the time evolution of non stable samples and it makes the experiment feasible in the clinical practice for detection of abnormal tissue. Here we present recent advances in development of the novel exchange time weighted MRI technique. The fast low angle shot (FLASH) imaging sequence [4,5] allows acquiring a 2D slice in less than 300 ms. It can be combined efficiently with the FEXSY image weighting in order to provide quantitative spatially resolved information on molecular exchange time and intra-cellular volume fraction. The experiment, which can be performed in only about 5 min, was implemented on a Bruker AVII-500 NMR spectrometer equipped with a MIC-5 probe giving maximum 3T/m magnetic field gradient strength. The micro-imaging equipment allows to obtain spatially resolved information with the in-plane pixel size of about 0.1x0.1 mm^2. With our pilot experiments we can demonstrate that the technique is useful in studying the yeast sedimentation process and to detect changes induced in yeast cells by temperature variations or addition of agents like dish washing soap, which influence the transport and structural properties of cells.

References

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