Single Shot Exchange Rate Quantification using Turbo PS-WEX

NMJ Plaehn[2,3], J Balling[1], S Mayer[1,4], PM Jakob[1], FT Gutjahr[1]
[1]University Würzburg, Experimental Physics 5, Würzburg, Bavaria, Germany
[2]Department of Diagnostic, Interventional and Pediatric Radiology, Bern University Hospital, Switzerland
[3]Translational Imaging Center (TIC), Swiss Institute for Translational and Entrepreneurial Medicine, Bern, Switzerland
[4]Leibniz Institute of Plant Genetics and Crop Plant Research (IPK), Seeland Gatersleben, Saxony-Anhalt, Germany.

INTRODUCTION:

Water Exchange Spectroscopy (WEX)[1] is a commonly used technique for the spectroscopic estimation of exchange rates by variation of an exchange interval (t_m). Recently phase sensitive WEX (PS-WEX) has been proposed as an extension to the WEX, in which an additional refocusing pulse within t_m simplifies fitting, by removing the T1-dependence of the signal evolution. In CEST, QUESP has become the gold-standard for exchange rate quantification, in which the field-strength of the saturation pulse is varied. Unlike QUESP, WEX allows the direct estimation of exchange rates in the time domain, which can be advantageous, while at the same time offering high spectroscopic resolution which can be obscured in QUESP-based measurements with higher saturation field strengths. However, from a sensitivity standpoint WEX is comparatively inefficient, as it does not exploit the accumulation of signal through multiple exchanges between a small pool and the much larger water pool.

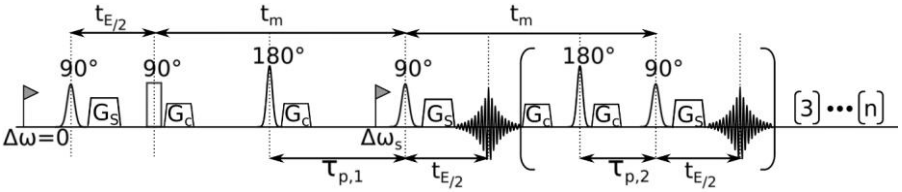

Figure 1: Sequence diagram of Turbo PS-WEX, flags signify a frequency change.

In this work we propose a method for single shot exchange rate quantification using the multiple transfer of magnetization after a single preparation, therefore exploiting the pool size difference.

METHODS:

In WEX the final readout of the previously prepared stimulated echo uses a WATERGATE-scheme to ensure that non-exchanged water magnetization does not contribute to the signal. By replacing this WATERGATE-readout by a frequency selective pulse on the exchanging pools of interest, the water pool can remain undisturbed by the readout. This enables to read out the exchanging magnetization repeatedly after single preparation. Fig. 1 shows the proposed sequence diagram for turbo PS-WEX. The position of the refocusing pulse within the mixing time is varied between echoes, to sample the accumulation of magnetization.

A number of vials containing 50 mMol/l creatine solutions with different pH-values were measured using WEX, PS-WEX and the accelerated Turbo PS-WEX. All measurement were done on a 17.5 T imaging system.

RESULTS and DISCUSSION

Signal curves for one of the vials as well as fitted exchange rates for all vials are shown in Fig. 2. Exchange rates acquired using single shot Turbo PS-WEX correspond well to exchange rates estimated using WEX and PS-WEX. While PS-WEX removes the T1- dependence from the signal evolution, Turbo PS-WEX reintroduces this dependence. This is expected to lower the fit accuracy in low SNR settings. The same acceleration principle also works with (non-PS) WEX (not shown here).

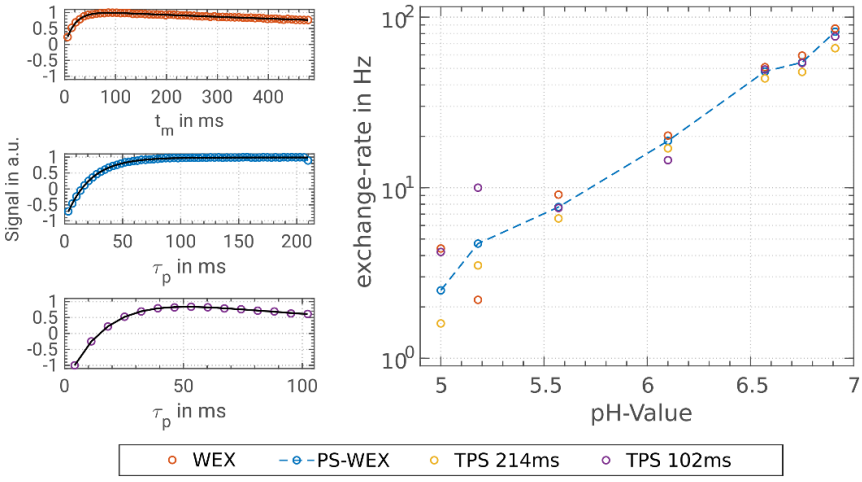

Figure 2: Left: Phase-corrected experimental data and corresponding fit for a WEX-, PS-WEX- and Turbo PS-WEX-experiment (Creatine 6.57), Right: Exchange Rates for multiple samples estimated from WEX-, PS-WEX- und Turbo-PS-WEX (with two different mixing-times t_m) in dependence on pH-Value.

CONCLUSION:

Turbo PS-WEX was shown to be a method for fast spectroscopic exchange rate quantification. This can increase throughput or be used for WEX imaging (see abstract J Balling).

REFERENCES:

1. Mori S, J. Am. Chem. Soc. 1994; 10.1021/ja00105a044
2. Plaehn NMJ, J Magn Reson. 2022 Feb:335:107141. 10.1016/j.jmr.2021.107141