

# Towards signal enhancement of glycogen C<sub>2</sub>-C<sub>6</sub> by localized <sup>13</sup>C MRS at 7T using broadband <sup>1</sup>H-decoupling and NOE by means of bi-level WALTZ cycles

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## Introduction

Localized <sup>13</sup>C MRS at 7T allows distinct detection of natural abundance glycogen C<sub>2</sub>-C<sub>6</sub> carbon resonances [1]. The utility of these resonances for investigating glycogen metabolism relies on their basic <sup>13</sup>C relaxation properties [2] which, to the best of our knowledge, have not been yet reported at 7T. In particular, in addition to the improvement in spectral resolution from broadband <sup>1</sup>H-decoupling using the WALTZ16 scheme [3], the sensitivity of the <sup>13</sup>C signals of glycogen C<sub>2</sub>-C<sub>6</sub> may be increased via the NOE using WALTZ cycles. In this context, the aim of this study was to develop and implement a pulse-acquire sequence for sensitivity-enhanced localized <sup>13</sup>C MRS using broadband <sup>1</sup>H-decoupling and NOE by WALTZ cycles, and to investigate the signal enhancement of glycogen C<sub>2</sub>-C<sub>6</sub> at 7T.

## Methods

In vitro <sup>1</sup>H-decoupled <sup>13</sup>C MRS measurements of glycogen C<sub>2</sub>-C<sub>6</sub> were performed on a 7T human-scanner (Siemens Erlangen/Germany) using a home-built <sup>13</sup>C-linear/<sup>1</sup>H-quadrature RF surface coil. A pulse-acquire sequence for localized <sup>13</sup>C MRS was designed as described previously [1, 4, 5]. In addition, an optimized NOE scheme using a series of equidistant WALTZ cycles interleaved with time gaps (21ms duration/100ms pause) was inserted into the sequence for <sup>1</sup>H-saturation during the <sup>13</sup>C-relaxation period. The performance of the NOE scheme was investigated in vitro on a phantom containing 800mM natural abundance of glycogen, using the C<sub>4'</sub> resonance at the centre of the <sup>13</sup>C MR spectrum. Besides, a pulse-acquire sequence based on the inversion recovery method was developed for adiabatic <sup>13</sup>C T<sub>1</sub> measurements of glycogen.

## Results and discussion

The <sup>1</sup>H-decoupled <sup>13</sup>C MR spectra of glycogen C<sub>2</sub>-C<sub>6</sub> without and with NOE were compared (Figure 1). Efficient and simultaneous <sup>13</sup>C signal enhancement of all glycogen carbons was achieved, i.e. ~ 1.4, 1.5, 1.4, 1.6, and 1.6 signal enhancement for glycogen C<sub>4</sub>, C<sub>3</sub>, C<sub>2,5</sub>, C<sub>4'</sub> and C<sub>6</sub>, respectively. In addition, the NOE of glycogen C<sub>1</sub> was ~1.5 (not shown). In particular, all NOEs were found to be higher than those encountered in the literature [2]. The <sup>13</sup>C spin-lattice relaxation times (T<sub>1</sub>) in vitro were ~0.35s and 0.15s for glycogen C<sub>2</sub>-C<sub>5</sub> and C<sub>6</sub>, respectively. A plausible explanation of the slightly higher T<sub>1</sub> values compared to [2] could be attributed to differences in rotational correlation times of the samples. In either case, the T<sub>1</sub> of glycogen C<sub>6</sub> was found to be half of those of glycogen C<sub>2</sub>-C<sub>5</sub>, in agreement with [2], as attributed to its two bonded protons.

## Conclusion

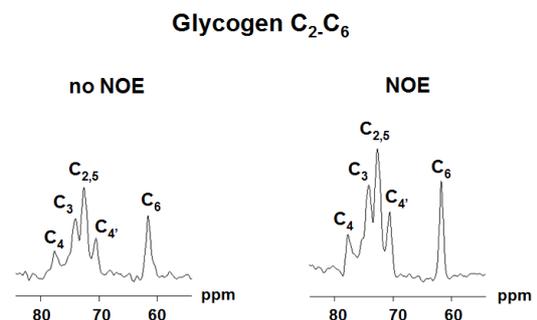
These preliminary results obtained from in vitro measurements of glycogen demonstrate the feasibility of the NOE scheme using WALTZ cycles to enhance the <sup>13</sup>C signals of glycogen C<sub>2</sub>-C<sub>6</sub> at 7T. Further investigation of differences in <sup>13</sup>C MR relaxation properties of C<sub>1</sub>-C<sub>5</sub> versus C<sub>6</sub> carbon resonances will allow a deeper understanding on their utility for investigating glycogen metabolism at ultra-high field.

## References

- [1] Serés Roig E. et al, 2016 ISMRM. [2] Sillerud LO. et al, Biochemistry 1983; 22, 1087-1094. [3] Shaka A.J. et al, JMR 1983; 53:313-340. [4] Tkac I. et al, App. Magn. Reson. 2005; 29:139-157. [5] Oz G. et al, Appl. Magn. Reson. 2005; 29, 159-169.

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**Figure 1:** <sup>1</sup>H-decoupled <sup>13</sup>C MR spectra of glycogen C<sub>2</sub>-C<sub>6</sub>, without and with NOE using 4 WALTZ cycles (21ms duration / 100ms pause), TR=1.1s.