A Measurement of the Magnetization Exchange Between the Different Water Compartments in Optic Nerve

H. Shinar[1], U. Eliav[1], G. Navon[1]

[1]School of Chemistry, Tel Aviv University, Tel Aviv, Israel

Introduction: The ^{2}H double quantum filtered (DQF) spectrum of isolated nerves equilibrated in deuterated saline consists of distinct pairs of quadrupolar split satellites corresponding to water in the different nerve compartments. Using this technique we have previously reported for rat sciatic nerve the observation of 3 pairs of quadrupolar split satellites, which were assigned to the epineurium, endoneurium and axon (1). The main advantages of DQ filtering is (a) the signal of the isotropic water is filtered out allowing for a better resolution of the quadrupolar split satellites and (b) the intensity of the different signals in the DQF spectra depend on the creation time of the DQ coherences, τ , allowing to selectively observe the desired signal. Thus we were able to measure the ^{2}H relaxation times and the water diffusion coefficients in the three compartments (2). Here we report a study of a bovine optic nerve where an additional compartment is observed and the magnetization exchange between the compartments were measured.

Materials and Methods: Bovine and pig optic nerves were equilibrated in deuterated saline and placed in the NMR tube with the long axis of the nerve parallel to the magnetic field .^{2}H in-phase DQF (IP-DQF) (3) spectra were measured at various creation times τ by the following pulse sequence: 90^0 - τ - 90^0 - t_{DQ} – 90 - τ - 90^0 - t_{ZQ} - 90^0 - Acq. t_{DQ} and t_{ZQ} are the DQ and zero quantum evolution times respectively

Results: The ^{2}H IP-DQF spectra of bovine optic nerve are given in Fig. 1. In addition to the central transition, three pairs of quadrupolar split satellites are observed. At short creation times, two pairs of very broad quadrupolar split satellites (ν_Q=1400 Hz, signal A; ν_Q=550 Hz, signal B) are evident. . One more pair of satellites (ν_Q=300 Hz, signal C) is evident at τ = 2 ms. At longer creation times, signals A, B, and C decay and a very narrow signal appears (D). In rat sciatic nerve we have assigned the splittings of approximately 500Hz, 200 Hz and the narrow signal to the water in the endoneurium, epinerium and the intraaxonal water respectively. The fact that for optic nerve the satellites with ν_Q =300 Hz (C) are very weak may indicate the relative small portion of this compartment. The broad pair of satellites, A, observed at the short creation times was previously not reported and may correspond to the myelin water.

In the magnetization exchange experiments we selectively excite signals A and B by using very short τ values and follow the evolution of the signals as a function of t_{ZQ} respectively. Some selected spectra of the magnetization exchange experiment, performed with τ = 0.05 ms, are given in Fig. 2 and the time course of the intensity of signals A, B and D is given in Fig. 3. While the decay of the broad satellites was in all cases multiexponential the buildup of signal D was monoexponential with a time constant of the order of 15 ms. This phenomenon was found also for pig optic and sciatic nerves. The reverse magnetization transfer from D to A and B could also be measured in an experiment with long τ values.

To the best of our knowledge, this is the first time that water exchange is detected between the different compartments of nerves.

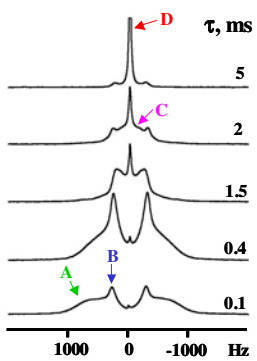

Fig. 1

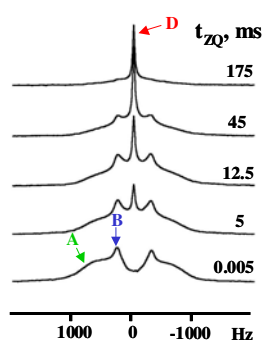

Fig. 2

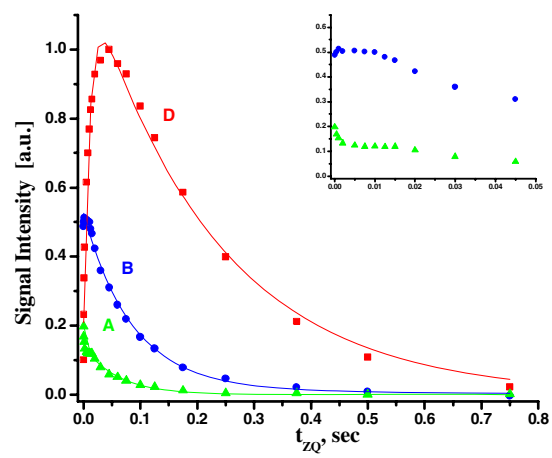

Fig. 3

References: 1. H. Shinar et al., J. Magn. Reson 129, 98 (1997).
2.Y. Seo et al., Magn. Reson. Med. 42, 461 (1999).
3. U. Eliav et al., J. Magn. Reson. 137,295 (1993).