Fruit Fly Meets Microcoils - A Magnetic Resonance Microscopy Investigation of Drosophilae

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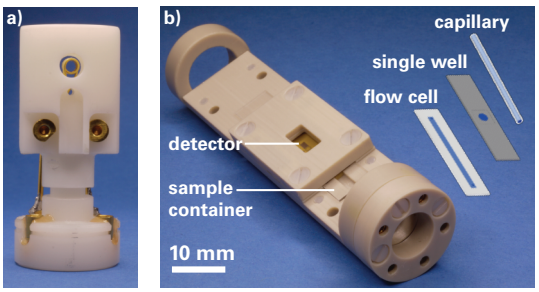
The fruit fly, i.e., Drosophila, is a model organism used extensively in medicine and biology. Magnetic resonance imaging (MRI) and localized spectroscopy (MRS) are powerful and well established methods to investigate the structure, metabolism or dynamics of organisms; such as, mice, rats, and others, due to their non-invasive and non-destructive nature which enables longitudinal studies. Utilizing the Bruker microcoils, Drosophila and other very small objects can be thoroughly studied using the same methods used for larger samples.

Using the different Bruker microcoils (Figure 1) ranging from solenoids to Helmholtz configurations, in combination with Bruker's state of the art microimaging cabinet, highly efficient imaging gradients (3 T/m) and ParaVision software (image acquisition and processing), Drosophilae can be investigated by acquiring a wide range of specific data from images and spectra.

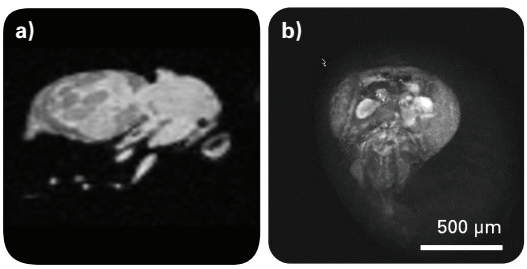
Selecting the right type and size of microcoil for the application enables an optimal result for the investigation. The microcoils differ in dimensions, sample sensitivities, flexibility and ease of use. High-resolution images of the morphology can be acquired in 2D and 3D, using a wide range of well established MRI methods. Depending on the requirements, images can be recorded of the whole body or individual parts, such as the head (Figure 2).

Figure 1



a) Solenoidal microcoil with a 2 mm glass capillary as sample container. b) Helmholtz microcoil with flow cell, PMMA well and glass capillary sample containers.

Figure 2



a) Drosophila full body placed in a glass capillary filled with Fomblin: Gradient Echo 3D image; FOV (4.2 x 2.1 x 2.1) mm^3; Resolution 16.4 µm isotropic; TR 50 ms; TE 5 ms; NS 24; T_{exp} 5h 27 min.
b) Drosophila head in tap water into a PMMA well sample container and sealed with a tape: Gradient Echo 3D image; FOV (1.5 x 1.5 x 1.5) mm^3; Resolution 12.5 µm isotrope; TR 80 ms; TE 2 ms; NS 164; T_{exp} 52 h 28 min.

Besides the morphology, additional information, such as, the water or fat distribution, T1, T2, or diffusion maps can be recorded within the fly's body.

Additional information can be obtained by utilizing an rf microcoil sensitive to a nuclei other than ^{1}H. For example: ^{31}P, ^{13}C, ^{19}F, ^{23}Na, etc..

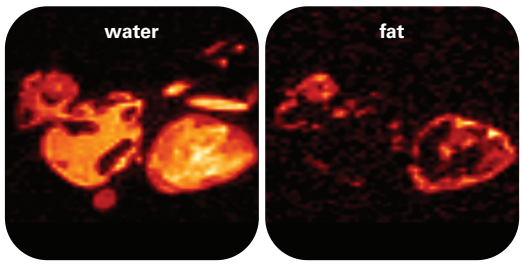
Utilizing standard spectroscopy, the microcoils allow information to be acquired from volumes in the nl range, (Figure 4).

Combining magnetic resonance microscopy with spectroscopy enables localized spectroscopy, i.e., acquiring spectra from morphologic relevant areas, i.e., defining a volume from which the NMR signal is only acquired. This volume can be precisely placed within ParaVision using previously acquired images. Typically used sequences for soft matter are PRESS (Point Resolved Spectroscopy) or STEAM (STimulated Echo Acquisition Mode) (Figure 5).

The CSI (Chemical Shift Imaging) sequence in contrast to the other two methods enables acquiring voxel-specific spectra of all voxels for the whole FOV (2D and 3D) at once. An example of a CSI of the drosophila's abdomen is shown where the spectra are super imposed with the morphological image (Figure 6).

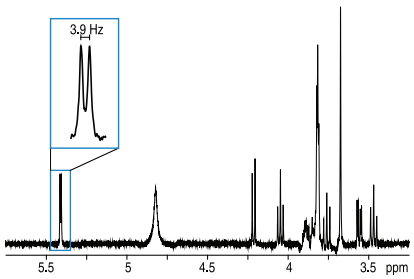
The Bruker microcoils are dedicated, powerful tools for investigating the micro regime, such as: drosophilae or other volume-limited samples, using state of the art magnetic resonance image and spectroscopy methods They were designed to combine high-sensitivity while being easy to use.

Figure 3



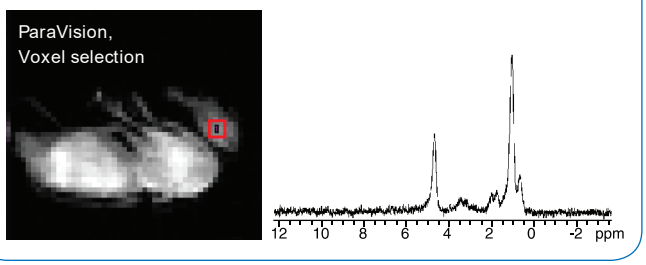
Chemical Shift Gradient Echo 3D image of a drosophila. FOV (3.2 x 2.2 x 2.2) mm^3; Resolution (50 x 34 x 34) μm^3; TR 50 ms; TE 2.1 ms; NS 4; T_{exp} 13 min;

Figure 4



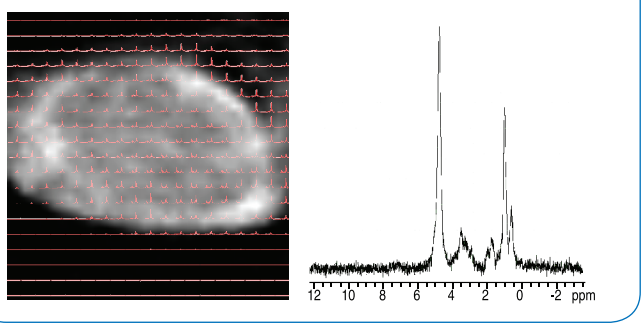
0.5 M sucrose in D_20 (90%) and H_20 (10%); (^{1}H, 500 MHz) in a glass capillary with an ID of 300 µm and OD of 500 µm. Active volume < 100 nl; TD 10k; SWH 5 kHz; AQ 1s; D1 0.1s, NS 64.

Figure 5



PRESS spectrum of the drosophila's brain region; V_{Voxel}(0.2 x 0.2 x 0.2) mm^3 = 8nl; TR 2 s; SWH 10 kHz; TD 4k; NS 512; T_{exp} 17 min.

Figure 6



Chemical Shift Image of a drosophila's abdomen. FOV (4.7 x 4.7 x 1) mm^3; Resolution (146 x 146 x 1000) μm^3; V_{Voxel} 20 nl; TR 1.8 s; SWH 6.5 kHz; TD 2 k; NS 16; T_{exp} 5 h 45 min.

- For more information, please contact: micdiff@bruker.com

All data was acquired on a 500 MHz Avance III HD, equipped with a micro 5 Probe , a micro 5 gradient, a MICLAB 500 ^{1}H HELM 1000UM VS1 insert and a 2 mm solenoidal microcoil.