The New MIC CryoProbe™ for Microimaging

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Since the introduction of CryoProbe™ technology for high-resolution NMR applications, a large variety of probe models has been developed and introduced to the market, as described in an overview article in this SpinReport. Here we wish to introduce the newest application for CryoProbe technology – microimaging.

The microimaging CryoProbe (MIC) is the latest addition to the CryoProbe family and features a ^{1}H rf channel operating at 400 MHz. The MIC CryoProbe is designed to handle 5-mm diameter samples, which can be inserted into a spinner and then into the magnet via the top bore tube in the usual manner. Sample temperature can be controlled over the range 0 - 80 °C.

The body of the MIC CryoProbe has an outer diameter of 40 mm so that it fits into Bruker's Micro2.5 gradient system, taking advantage of the proven high-performance gradient technology already available for the conventional noncryogenic microimaging probes. The Micro2.5 gradient system, in turn, fits into the standard wide-bore shim system used on vertical wide-bore magnets with bore diameter of 89 mm or more (**Fig. 1**). This adaptation of separate probe and gradient systems is analogous to that used for the HR-MAS-PFG system described in another article in this SpinReport.

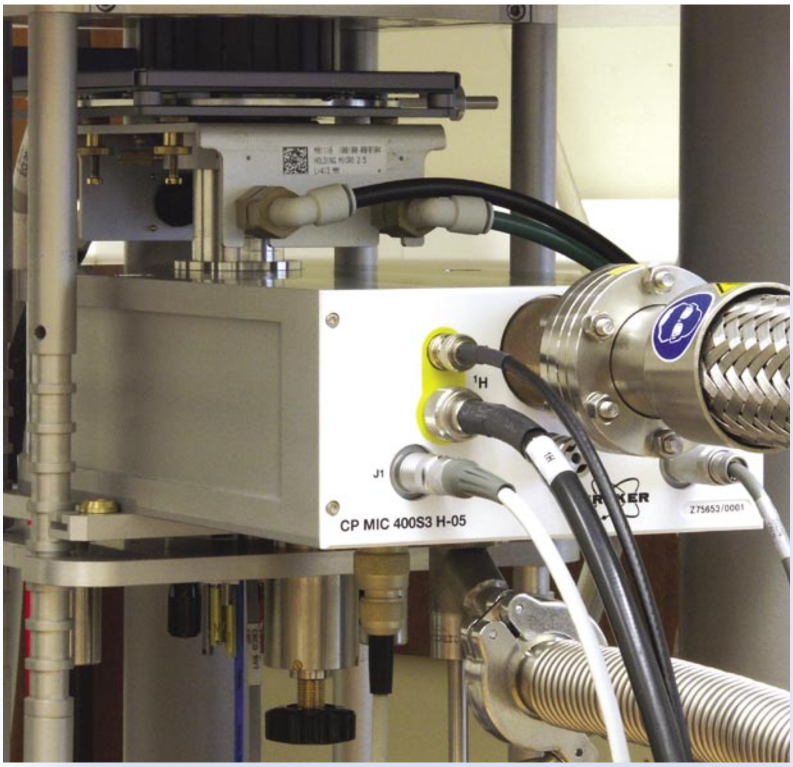

Fig. 1: The 400 MHz MIC CryoProbe™ installed in a wide-bore magnet. Visible in the middle area are (from top to bottom) the flange of the CryoProbe Mounting Hardware against the base of the magnet, the wide-bore shim system (tube and base flange), the base of the Micro2.5 gradient system with two hoses for cooling water connected, and the base of the CryoProbe with electrical and cryogen connections. The pillars and horizontal platform of the Mounting Hardware can be completely removed when not in use, ensuring unrestricted access to the magnet bore for mounting conventional probes.

The MIC CryoProbe is fully compatible with all of Bruker's conventional microimaging hardware and with the same CryoPlatform hardware used with any CryoProbe for high-resolution spectroscopy. Thus, MIC CryoProbe operation is straightforward and transparent to the user, and upgrading to MIC CryoProbe technology is particularly simple (and economic) if a Micro2.5 gradient system and/or a CryoPlatform are already part of the existing spectrometer equipment. However, it will be necessary to verify that the magnet system has sufficient floor clearance, and a minor system upgrade, the MIC CryoProbe Mounting Hardware, is required. After the spectrometer has been set up with the MIC CryoProbe, the system remains compatible with all other CryoProbes and all conventional microimaging or spectroscopy probes. Thus, the user can reconfigure the spectrometer and switch between different applications in the usual straightforward manner.

The main benefit of the MIC CryoProbe is the same as for any high-resolution spectroscopy CryoProbe – a dramatic enhancement of detection sensitivity, i.e., about a factor of 4 compared to the corresponding noncryogenic probe. This allows a reduction of voxel volumes by the same factor for a given measurement time or a reduction of measurement time by up to a factor 16 at constant resolution.

Thus, the exceptional performance of the MIC CryoProbe system facilitates many new applications in the following areas:

- ❑ botany,
- ❑ embryology,
- ❑ clinical histology,
- ❑ studies of insects and other small organisms,
- ❑ studies of rapid dynamic processes,
- ❑ localized spectroscopy of nanoliter voxels,
- ❑ studies of porous and inhomogeneous objects at an intermediate field strength with high sensitivity and minimal susceptibility distortions.

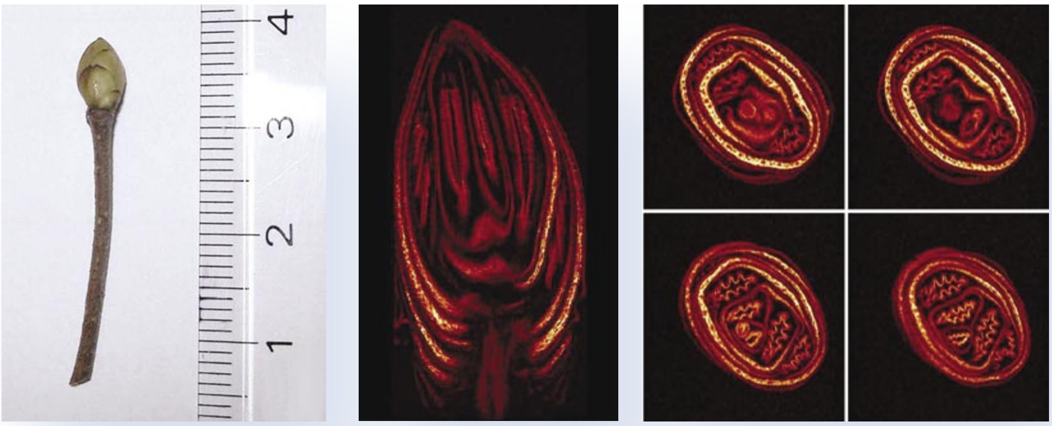

Fig. 2: Images of a Lilac bud in the spring growth phase.
Left: optical image showing that the bud has the ideal size for the MIC CryoProbe (ca. 4 × 7 mm).
Middle: 400 MHz ^{1}H spin-echo image of a 200-μm coronal slice (512 × 256 pixels, TR/TE = 750/8.7 ms, 8 averages in 25.6 min, 15.6 × 15.6 μm in-plane resolution).
Right: spin-echo images of four 300-μm transverse slices (256 × 256 pixels, TR/TE = 1000/5.8 ms, 1 average in 4.3 min, 19.5 × 19.5 μm in-plane resolution.

The potential benefits of the MIC CryoProbe and its exciting applications are currently being investigated with various samples and methods. For example, **Fig. 2** shows the distribution of water in a lilac bud during the spring growth phase and demonstrates that very high resolution in acceptable imaging times is achieved. **Fig. 3** illustrates the ability to study morphology and local differences in water and fat distribution in wild-type vs. mutant Drosophila.

The examples presented here illustrate just a few of the many potential applications of this new generation of equipment for NMR microimaging. The standard MIC CryoProbe used for these studies operates at 400 MHz for ^{1}H; systems for 500 and 600 MHz are available upon request.

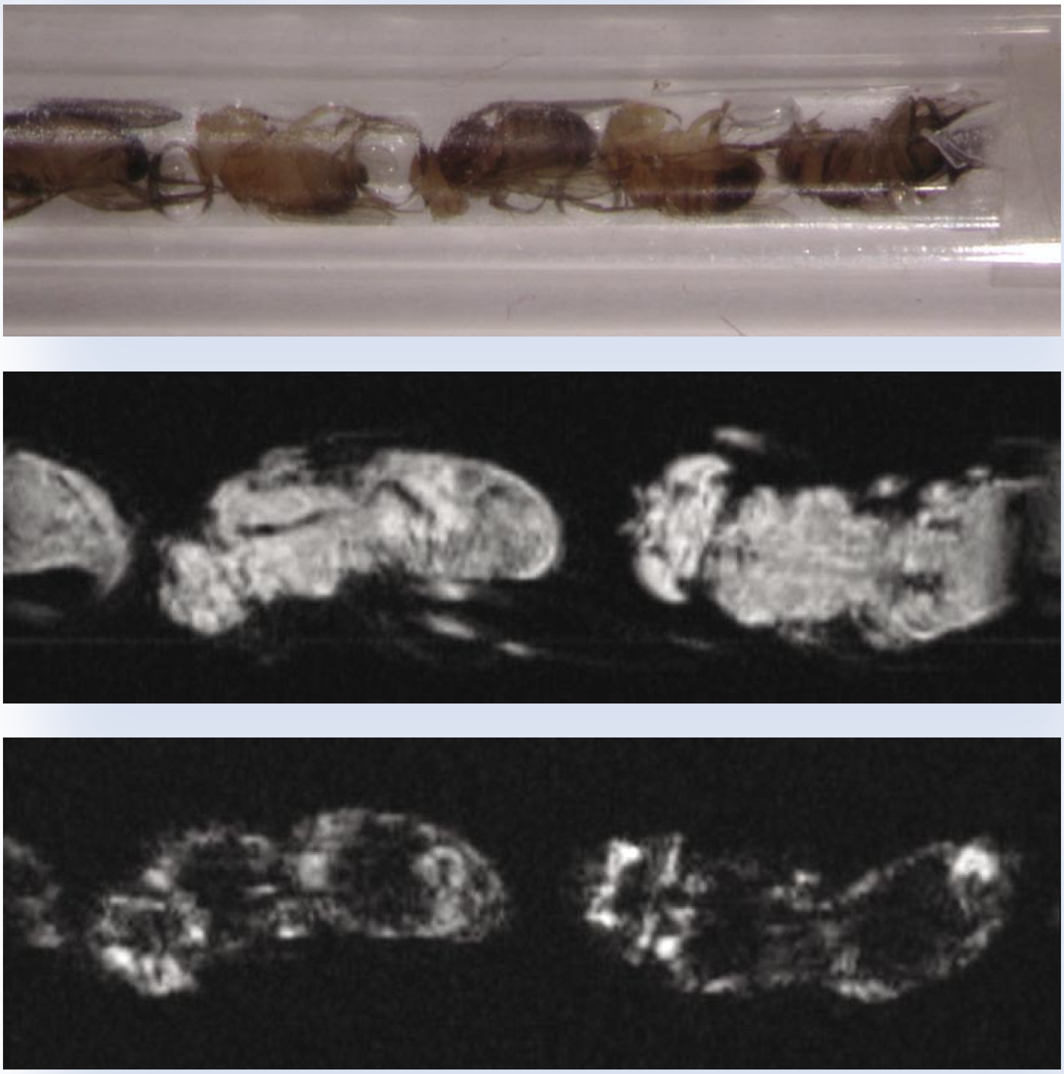

Fig. 3: ^{1}H microimaging of Drosophila (fruit fly) at 400 MHz.
Top: optical image of the specimen; the volunteers were placed in Fomblin® oil (a perfluoro polyether) in a 3-mm glass tube which was then inserted into a 5-mm NMR tube. A spin-echo sequence was used to obtain a 3D data set of 256 × 64 × 64 voxels with dimensions 21 × 28 × 28 μm (TR/TE = 500/9.8 ms, 16 averages in 9.1 h). The water (**middle**) and lipid (**bottom**) distributions are shown for one longitudinal 2D plane from the 3D data set, comparing a wild-type Drosophila (left) with a mutant (right). The voxel volume is ca. 16.5 pL.

Sample courtesy of B. Simon, A. Teleman, S. Cohen, M. Sattler, EMBL, Heidelberg, Germany.