Chemical Shift Imaging by precise object displacement

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We present here an instrumental arrangement by which the vertical position of the sample is settled in a very precise way, the aim being to obtain the NMR spectrum in as many thin slices as fixed by the step-by-step displacement of the sample. This is nothing less than one-dimensional chemical shift imaging (CSI) with a spatial resolution not dictated by the magnetic field gradient amplitude or by the corresponding pulse sequence but rather by the accuracy of the sample displacement combined with the spatial selectivity of the radio-frequency field (rf field or B_1 field) employed in the relevant NMR experiment.

This is achieved using a stepper motor installed at the top of a vertical cryomagnet. A series of gears transform the rotation into a translation motion applied to an endless screw, this motion being controlled by an optical device (precision : 2 μm).

Generally, sample displacements are much smaller than the slice thickness; as a result, the spectrum measured at each sample position corresponds to overlapping spatial regions. Knowing the vertical radio-frequency (rf) field profile (the amplitude of the rf field along the vertical direction), it is possible to reconstruct by an appropriate algorithm the spectrum associated with all the slices corresponding to consecutive sample positions and to improve the spatial resolution, which is simply related to the accuracy of the displacement device.

Besides tests performed on phantoms, the method has been applied to solvent penetration in polymers and to gaz diffusion in a heterogeneous zeolite medium. In the latter case, the results obtained were compared to results obtained with numerical simulations.