International Symposium and Summer School NMRCM 2014 Saint Petersburg, Russia

Registration of magnetic resonance from nuclei other than protons on 0.5 Tesla MRI scanner

Nikolay V. Anisimov, O. Pavlova, M. Gulyaev, A. Samoylenko, Yu. Pirogov

Faculty of Fundamental Medicine, Lomonosov Moscow State University, Moscow, Russia
E-mail: anisimovnv@mail.ru

Introduction

In this paper we report on additional technical capabilities that were found in a typical MRI scanner – Bruker Tomikon S50 (0.5 T). These may be employed for a wide range of NMR applications – high resolution NMR spectroscopy (MRS), MRI and NQR. The main attention is directed to detecting fluorine (^{19}F) signals. Interest in this nucleus consists in prospects to use perfluorocarbons as blood substitutes and MRI contrast in medicine [1].

Materials and methods

This study was initially focused on registering fluorine nuclei. It turned out that the resonant circuit, which includes a built-in magnet gap transmitter coil, is tuned only on the proton NMR frequency (21.08 MHz). It can be not retuned on the fluorine NMR frequency (19.83 MHz). Therefore, we were looking for other options for the transmitter coil and adopted firm resonator intended for the study of the knee. By modifying its electronic components it has been transformed to work as a transceiver. Measurements were preceded by experiments using the homemade transceiver probeheads. As a result we have gained experience registering MRS not only from the proton ^{1}H and fluorine ^{19}F, but other nuclei - phosphorus ^{31}P, carbon ^{13}C, deuterium ^{2}D. Their resonant frequencies are respectively, 8.53, 5.30 and 3.24 MHz. For some nuclei other than protons (^{19}F and ^{31}P), technique to obtain MRI images was debugged. In addition, ^{35}Cl NQR signal from powdered $KClO_3$ placed outside of the polarizing magnet was successfully registered.

Results

By optimizing the parameters of the transceiver coils (design and location), MRS is possible without the long-term accumulation of signals. A large number of scans (~10^3 or more) is required only for nuclei with low natural abundance - ^{13}C, ^{2}D. The MRS and NQR from other above mentioned nuclei were recorded with a single scan. The same applies to isotopically enriched nuclei. Examples of MRS and MRI are shown in Figure 1.

Left: the ^{19}F MRS and MRI (one of 5 slices in two projections) from a cylindrical vessel (H/Ø = 4/2 cm) filled with perfluorocarbon. These MR images were obtained in 1 minute using multiple spin-echo - TR/TE_{min}=470/12.5 ms, ETL=8, (in-plane resolution 1 mm, slice thickness 1 cm.

Center: ^{13}C MRS of ethanol after 1.5 hours signal accumulation, Right: ^{35}Cl NQR spectrum from from powdered $KClO_3$ after one scan.

Discussion

It is interesting that according to firm documentation, the MRI transceiver tract is not suitable for registration of nuclei other than protons. Indeed, an output RF amplifier LPPA 2120 (Dressler) and a preamplifier HPPR (Bruker) equipped with filter X-BB31P have the bandwidths declared: 19-22 and 12-32 MHz respectively. Really their bandwidths are much broader. Probably the MRI manufacturer is interested only in narrowly targeted use of its products. Therefore it declares only those characteristics that lead away from the temptations to use the equipment for questionable applications. May be that's why transmitter coil was specially designed so that it cannot be tuned to 19.83 MHz.

Conclusion

We revealed significant potential for use of the MR scanner for multi-nuclear magnetic resonance applications. The results obtained by MRI and MRS fluorine nuclei give reason to hope that the registration of these nuclei can be carried out and not only in studies of laboratory animals , but also man. Obvious the registration of the NMR spectra in weak fields (0.5 T) is of only methodological interest. MRI is of interest in any field. But registration of nuclei other than protons and fluorine in weak fields is while not widespread due to insufficiently high sensitivity of the method. As for NQR, this method is now little used in structural studies, not at least because of the lack of specialized equipment. MRI and NMR spectroscopy equipment can be adapted to solve this problem.

References

[1] G. Schnur, R. Kimmich, R. Lietzenmayer. - *Magn. Reson. Med*., **13** (3), 478-489 (1990).
[2] Tomikon - Avance System. Technical Description. Doc. No.: T2J-1122, T4-J1133 (1996).

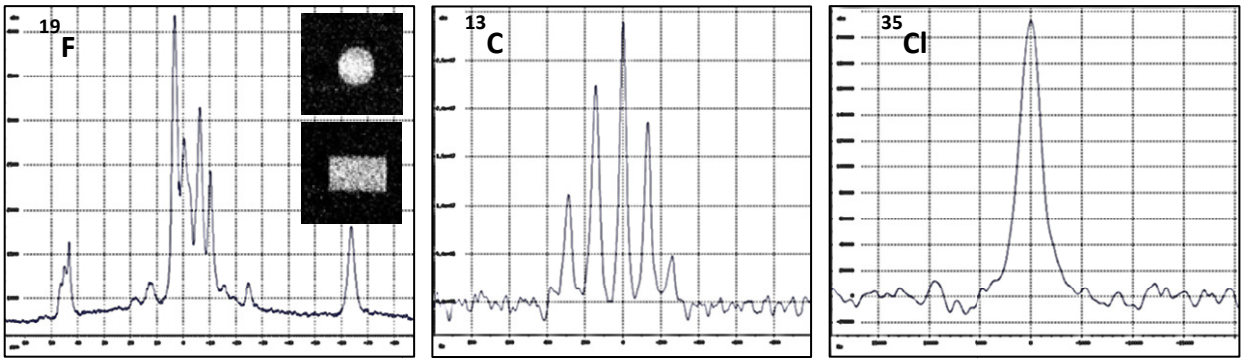

Figure 1. MRI, MRS and NQR specta which were obtained using 0.5 T MRI scanner. Spectrum widths are 3.2, 2, 40 kHz