Application of high-temperature superconductor yields world's highest magnetic field

1 July 2015

A part of the recently developed 1,020 MHz-NMR system equipped with superconducting magnets (about 5 m high and weighing about 15 tons). This part contains coils made of a high-temperature superconductor. Liquid helium is used for cooling.

A Japanese research team has successfully developed a nuclear magnetic resonance (NMR) system equipped with the world's highest magnetic field, 1,020 MHz. In addition, taking actual measurements with this new system, the team confirmed its considerably enhanced performance compared to conventional NMR systems in terms of sensitivity and resolution.

NMR systems have been used for various purposes including 3D conformational analysis of biopolymers such as proteins, organic chemistry and materials research. In particular, it is one of the indispensable tools for the development of new drugs. In the development of a new drug, it is vital to understand protein structures in a quick and accurate manner. In this view, improving the performance of NMR systems is of great importance. Magnetic field strength is a key indicator of the performance of NMR systems, and thus there had been fierce competition to develop NMR systems with magnetic fields greater than 1,000 MHz. For a long time, it was broadly expected that the use of high-temperature superconducting technology would enable producing magnetic fields above 1,000 MHz. However, because high-temperature superconductors had problems such as being fragile and difficult to process, no party had achieved their practical use for a long run.

Through developing several new technologies including the conversion of the high-temperature superconductor developed by NIMS in 1988 into the form of wire material, the research team recently created the NMR system equipped with world's highest magnetic field at 1,020 MHz. Before making this accomplishment, the team spent 20 years of planning, designing and construction, as well as overcoming many hardships such as suspension of the project due to the damage to the nearly completed system caused by the Great East Japan Earthquake, encountering a serious worldwide shortage of helium supply, and the sudden passing of the team leader.

It is expected that the super-high magnetic field NMR will greatly contribute to various fields such as structural biology, analytical chemistry and materials engineering. Furthermore, considering

that NMR requires a magnetic field with extraordinary precision, the high-temperature superconducting technology that was cultivated during the development of NMR is applicable to various high-tech systems such as MRI (magnetic resonance imaging), nuclear fusion, linear motor trains and superconducting power cables.

A part of this study was published in the *Journal of Magnetic Resonance* on May 15, 2015, and was presented at the Experimental Nuclear Magnetic Resonance Conference, the largest international conference on NMR, held from April 19 to 24 in the United States, and at the 57th Solid-State NMR and Materials Forum held on May 21, 2015 in Japan.

More information: "Achievement of 1020 MHz NMR," *Journal of Magnetic Resonance*, Volume 256, July 2015, Pages 30-33, ISSN 1090-7807, dx.doi.org/10.1016/j.jmr.2015.04.009

Provided by National Institute for Materials Science