

Development of Sodium-23 MRI Systems

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Summary

The purpose of the present work is to develop a magnetic resonance imaging (MRI) system that can directly observe sodium-23 stable-isotope in living organisms. Sodium is one of the most important elements involved in various physiological activities in a human body. Generally, the element that MRI systems observe is a hydrogen atom, the contrast of which is imaged; if the MRI signal strength is high, a clear image can be obtained, but if the signal strength is weak, imaging becomes much difficult. Although the natural abundance of sodium-23 is 100 %, it is well known that the Larmor frequency of sodium-23, which is a specific value, is much lower than that of hydrogen atoms. Here, a sodium-23 MRI system, using an ultra-sensitive MRI signal receiver coil with high-temperature superconducting material (HTS), is being developed.

Due to the change of my institutional affiliation during FY2024, the research facility including MRI systems had to be relocated. Therefore, the research plan was slightly changed backward. In the present report, the results of MRS (solid-state NMR, Nuclear Magnetic Resonance) measurements on chlorine-35 stable-isotope, which is a quadrupolar nucleus and has a physicochemical property similarly to that of sodium-23, and a high sensitivity demonstration of HTS coil, are given.

Using a new method proposed by the applicant, which combines a zero-field solid-state NMR technique with a field-stepwise-swept solid-state NMR one, the solid-state ^{35}Cl NMR spectra of polychlorotrifluoroethylene, a chlorine-containing polymer, can be successfully observed and the related ^{35}Cl NMR parameters are analyzed. The findings obtained in the present work will be applied to future sodium-23 MRI measurements.

A high-sensitivity demonstration of the HTS coil is performed. Solid-state bromine-79 NMR spectra of a polycrystalline potassium bromide are observed under the identical measurement conditions (the same pulse sequence, number of scans, measurement temperature, etc.) using copper and HTS coils. The signal-to-noise ratios are compared, demonstrating that the HTS coil shows a sensitivity improvement rate of more than 6 times. The Q-values of both coils are measured, indicating that this sensitivity enhancement ratio is consistent with the theoretical sensitivity enhancement ratio calculated from the Q-values.