MERIT Internship Report

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MERIT 10th student

【Institution】

RIKEN Center for Sustainable Resource Science, Molecular Structure Characterization Unit（Prof. Takashi Nakamura）

【Overview】

From June 20th to July 31st, 2024, I joined an internship under Professor Takashi Nakamura of the Molecular Structure Characterization Unit at the RIKEN Institute on the theme of "Analysis of Adhesive Interactions Using Solid-State NMR."

【Background】

I decided to pursue this internship for three main reasons:

(1) Deepen knowledge of solid state NMR: I aimed to enhance my understanding of solid-state NMR, which is crucial for analyzing adhesive interactions.

(2) Work with Prof. Nakamura: I sought the opportunity to conduct experiments under the guidance of Professor Nakamura, a leading expert in solid-state NMR, and to initiate collaborative research.

(3) Experience a research environment: I wanted to explore the research environment and culture at a research institute, which differs from that of a university setting.

Because the compounds used in this analysis of adhesive interactions are given that the compounds used in adhesive interaction analysis are chemically stable and challenging to measure with solution NMR, my goal for this internship was to perform solid-state NMR measurements under Professor Nakamura’s supervision at RIKEN and to embark on collaborative research projects

【Contents】

Since this topic has not yet been published, specific details are not provided here.

Fluorine-containing polymers, such as polytetrafluoroethylene (PTFE), are utilized in various applications including tableware, medical equipment, coatings, and electronic materials due to their exceptional chemical and thermal stability. This high chemical stability of PTFE is attributed to its C-F bonds. However, PTFE's chemical inertness also results in poor adhesive properties. Consequently, PTFE surfaces typically require special treatments to improve bonding with other materials. I developed an adhesive capable of bonding PTFE without the need for surface treatment. This adhesive contains fluorine atoms, but when we used a version of the molecule with fluorine replaced by hydrogen for comparison, it failed to bond with PTFE. Control experiments indicated that the fluorine atoms in the adhesive likely interact with the C-F groups on the PTFE surface through fluorine-fluorine interactions. Therefore, the objective of my internship was to experimentally analyze these interactions using solid-state NMR.

Initially, I was trained on the principles and methods of measurement and then began analyzing my samples. During the first few weeks, I faced challenges with sample preparation, including difficulties in achieving a stable rotation speed and optimizing conditions for clear spectra. After adjusting the measurement conditions and temperature, I successfully obtained NMR spectra for ^{1}H, ^{13}C, and ^{19}F nuclei. These spectra suggested the formation of hydrogen bonds and fluorine-fluorine interactions within the adhesive, providing valuable data for this research.

Subsequently, we aimed to analyze the interaction between the adhesive and PTFE particles. We planned to vary the ratio of the two compounds and conduct measurements; however, equipment malfunctions halted the process midway. Although we only managed to perform ^{13}C NMR before the breakdown, the spectrum was nearly identical to those obtained with only adhesive or only PTFE, so no significant information was gained at that stage. Despite not completing the experiment during my MERIT internship, we achieved promising results from the solid-state NMR measurements of the adhesive alone. We intend to continue collaborating with Professor Nakamura and plan to perform ^{19}F NMR measurements in the future.

【Impressions】

During this practical training, I had no prior experience with solid-state NMR measurements, and initially, I struggled with sampling and optimizing measurement conditions. However, thanks to Professor Nakamura's clear and comprehensive explanations, along with his direct guidance on the nuances of the measurement techniques, I was able to successfully analyze the interactions within the adhesive.

His detailed advice on interpreting the results was invaluable, both during the measurements and the subsequent discussions.

Additionally, I took the opportunity to read several books on solid-state NMR, which significantly enhanced my understanding of the subject. RIKEN's extensive range of equipment and the frequent collaborative research and discussions among research groups create a highly stimulating and productive environment for researchers.

【Acknowledgements】

I would like to express my sincere gratitude to Professor Takashi Nakamura for accepting my request on such short notice and for agreeing to continue our collaborative research in the future. His support provided me with this invaluable experience. I also extend my thanks to the MERIT program and my supervisor, Professor Takuzo Aida, for offering me the opportunity to join this internship.