The main purpose of this project is to reveal the formation process of formamide (H_2NCOH). Formamide has been astronomically observed in interstellar space, and expected to play a significant role as a precursor of nucleobases which syntheses ribonucleic acid (RNA). The investigation of formation process of formamide will give new scientific findings about the origin of life in the universe.

In order to unravel a chemical reaction process, it is required to identify the reaction intermediates which are short-lived molecules using a highly sensitive method, but conventional techniques are not enough for the purpose in some cases. To satisfy the technical requirement, we develop an advanced spectrometer for mid-infrared absorption spectroscopy using state-of-the-art optical frequency comb techniques. The optical frequency comb is a kind of a broadband light source, but the broad spectrum consists of millions of modes with narrow linewidth. And the comb is widely used as a precise optical frequency ruler in the field of metrology and molecular spectroscopy. In this project, a mid-IR optical frequency comb (2.7- 5 μm) we have developed combines with Fourier–transform spectrometer (FTS). The comb-based FTS realizes high-frequency resolution and precision, and accuracy on the vertical axis surpassing conventional FTS. We can apply the comb-based FTS to time-resolved spectroscopy maintaining the ability of high-frequency resolution and precision. Furthermore, by applying comb-based cavity-enhanced spectroscopy, high sensitivity is achieved, which is necessary for the detection of reaction intermediates. We perform time-resolved high-frequency resolution infrared spectroscopy of the formation process of formamide by NH_2 radical and formaldehyde. This measurement will enable to identify the intermediates of the reaction, derive reaction rates, and verify the reaction process in interstellar space.

In this project, measurement with comb-based FTS will provide the spectra of some species with highest resolution and accuracy so far. The high resolution spectroscopic data of NH_2 radical is useful for the field of observational astrophysics. And analytical results of vibrational couplings derived from the high resolution data of formamide are valuable as a fundamental work in molecular physics.

In the field of chemical physics, clarifying the elementary processes of chemical reactions is a significant issue. The comb-based time-resolved FTS will be a powerful tool for the study of chemical reaction dynamics because of the high ability realized by incorporating state-of-the-art optical frequency comb-based spectroscopies.

The research of formation process of formamide is valuable to unravel the origin of life in the universe because of the high prebiotic potential of the formamide. Recently, a theoretical research proposed a reaction path of formamide, which can well explain the large abundances of formamide in interstellar space. However, the reaction process has not been experimentally verified. Therefore, scientists in the field of astronomy and prebiotic chemistry are waiting the experimental verifications. The reaction process unraveled by this project is expected to be the basis for discussions in the field of astronomical and prebiotic chemistry in the future.