How did the first building blocks of life emerge? Could simple chemical compounds have formed in space before reaching young planets? The project "Spectroscopic Prebiotic Signatures and PhotoChemical Evolution in Gas-to-Ice Astro Microenvironments" aims to investigate how molecules related to glycine—the simplest amino acid—and its precursors may form and evolve under interstellar conditions. Scientists suspect that these compounds could have originated in dense molecular clouds and on the surfaces of cosmic dust grains covered with ice, later undergoing transformations into increasingly complex structures under the influence of radiation. The results of this research may help answer the question of whether life could have had its origins in space.

To unravel this mystery, scientists will employ state-of-the-art research methods that combine laboratory experiments and theoretical modeling. At Chongqing University in China, individual molecules and their aggregates in the gas phase will be studied using Fourier Transform Microwave (FTMW) Spectroscopy, allowing for highly precise determination of their structure. Simultaneously, at the University of Wrocław in Poland, experiments will be conducted using matrix isolation techniques and infrared spectroscopy (FTIR), enabling the analysis of the same molecules under low-temperature conditions that resemble interstellar ice environments. These studies will be complemented by quantum chemical calculations, which will help predict the behavior of molecules and understand the mechanisms behind their formation and transformation.

One of the key aspects of the project is examining how radiation—from near-infrared to ultraviolet—affects the stability and reactivity of these molecules. In space, molecules are constantly exposed to starlight and cosmic radiation, which may cause their decomposition, bonding into larger structures, or the formation of entirely new compounds. By conducting controlled laboratory experiments, scientists will be able to determine which processes dominate and what types of products can form under these extreme conditions.

This research is highly significant for astrobiology, as it will provide new insights into the chemical evolution of matter in space. The results could help interpret astronomical observations, particularly data from the James Webb Space Telescope (JWST), which studies the chemical composition of molecular clouds and exoplanets. Furthermore, the project strengthens international collaboration between Poland and China, combining the expertise of Wrocław-based researchers in low-temperature spectroscopy with that of Chinese specialists in microwave spectroscopy and theoretical modeling. Joint research efforts will contribute to a deeper understanding of the processes that may have led to the formation of the first organic building blocks of life—not only on Earth but possibly on other planets across the Universe.