

## Abstract

Studying complex organic molecules in the interstellar medium (ISM) and planetary atmospheres is crucial for understanding their chemical compositions and complex biochemistry. The high- and low-mass star-forming regions, molecular clouds, and protoplanetary disks are ideal targets for observing complex molecular lines, as various molecules are formed and destroyed in these regions through gas-phase and grain-surface chemical reactions. In this thesis, we present molecular line observations towards hot molecular cores and hot corinos using the high-resolution Atacama Large Millimeter/Submillimeter Array (ALMA). Complex molecular lines in planetary atmospheres and cometary objects were also investigated. Several complex organic molecules were detected, including the possible precursors of the simplest amino acid, glycine ( $\text{NH}_2\text{CH}_2\text{COOH}$ ). We also successfully detected various nitrogen (N)-, oxygen (O)-, and thiol (SH)-bearing molecules in hot molecular cores and hot corinos. After detection, the column density and excitation temperature of these molecules were estimated using the local thermodynamic equilibrium (LTE) and rotational diagram models. The LTE assumption is valid in hot cores and corinos because the gas and kinetic temperatures are nearly equal. Following the column density estimation, we derived the fractional abundances of the detected molecules with respect to molecular hydrogen ( $\text{H}_2$ ). The detection of complex prebiotic molecules such as methylene imine ( $\text{CH}_2\text{NH}$ ), methylamine ( $\text{CH}_3\text{NH}_2$ ), cyanamide ( $\text{NH}_2\text{CN}$ ), and aminoacetonitrile ( $\text{NH}_2\text{CH}_2\text{CN}$ ), potential  $\text{NH}_2\text{CH}_2\text{COOH}$  precursors, provides insight into how complex molecules create biological environments through various chemical reactions. To understand the formation mechanisms of the detected complex

organic molecules, we employed two-phase warm-up chemical modelling at different timescales using gas-grain chemical codes UCLCHEM and GGCHEMPY. Additionally, the rotational emission line of hydrogen cyanide (HCN) was detected in the atmosphere of Saturn. To derive the abundance of HCN from the atmosphere of Saturn, a planetary spectrum generator (PSG) radiative transfer model with different atmospheric layers was used. Furthermore, we detected evidence of atomic hydrogen (HI) from the comet C/2020 F3 (NEOWISE) using the Giant Metrewave Radio Telescope (GMRT). This study opens new avenues for understanding prebiotic chemistry in the universe. The detection of chemically related complex organic and prebiotic molecules in both interstellar hot cores and Solar System bodies such as comets suggests that common grain-surface chemical pathways operating on icy dust mantles may be universal, bridging the chemistry of star-forming regions and planetary systems.

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