Chemical complexity driven by H_2 and carbon atoms: formation of sulfur-bearing molecules H_2CS and CH_3SH

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Molecular complexity in space develops through a combination of gas-phase and grain-surface reactions. The latter provide catalytic surfaces and efficient energy dissipation under the cold, dense conditions of molecular clouds. Although more than 330 molecules have been detected, mainly via rotational spectroscopy with facilities such as ALMA and NOEMA, recent JWST observations reveal that a rich chemistry is already present in pristine interstellar ices[1].

Despite extensive studies on atomic hydrogen addition, the role of molecular hydrogen (H_2) —the most abundant molecule in the universe—remains poorly understood. Theoretical work suggests that highly reactive carbon atoms could activate H_2 and open new non-energetic formation pathways for complex organic molecules (COMs)[2], but experimental tests are scarce.

We explore these routes for sulphur chemistry by investigating the formation of thioformaldehyde (H_2CS) and methanethiol (CH_3SH). Experiments were performed with the cryogenic ultra-high-vacuum setup SURFRESIDE[3], which co-deposits atomic (H/D, C) and molecular species onto cold gold substrates, monitored in situ by reflection-absorption infrared spectroscopy and analysed during warm-up by temperature-programmed desorption mass spectrometry.

These experiments provide new laboratory constraints for sulphur chemistry in cold cores and have implications for deuteration ratios and gas-phase abundances at later stages of star formation.

References

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