CONTROL ID: 2256632

TITLE: High deuteration and increased complexity of organics in the inner regions of solar-type protostars

ABSTRACT BODY:

Abstract Body: The early stages of low-mass star formation are known to be accompanied by the increase of the molecular complexity. Most of the lines detected in the sub-millimetric spectra of low-mass Class 0 protostars are attributed to Complex Organic Molecules (COMs; molecules based on carbon chemistry with 6 or more atoms) while a few COMs display an extremely enhanced molecular deuteration, a tool that allows us to trace the chemical evolution during star formation. The high abundances and deuterations of COMs observed towards low-mass protostars tend to be underpredicted by astrochemical models. This discrepancy might come from the large beam of the single-dish telescopes, encompassing several components of the studied protostar, commonly used to detect COMs.

To address this issue, we have carried out multi-line observations of different methanol isotopologues and several COMs toward the low-mass protostars IRAS2A and IRAS4A with the Plateau de Bure interferometer at an angular resolution of 2 ". The high number of detected transitions from COMs allowed us to accurately derive the source size of their emission and their column densities.

Among the different detected COMs, we report the first multi-line detection of the O-bearing species glycolaldehyde and ethanol and of the N-bearing species ethyl cyanide toward low-mass protostars other than IRAS 16293. The COM abundances with respect to methanol derived in this work are slightly, but not substantitally, lower than those derived from previous single-dish observations. The abundance ratios of most COMs do not vary significantly with the protostellar luminosity, over five orders of magnitude, implying that low-mass hot corinos are quite chemically rich as high-mass hot cores.

The multi-line detection of the deuterated methanol isotopologues CH2DOH, CHD2OH, and CH3OD also allowed us to derive a high deuterium fractionation of methanol, consistent with the D/H ratios derived with single-dish telescopes. In consequence, astrochemical models still underpredict the abundances and the deuteration of key COMs suggesting that our understanding of their formation remains incomplete.

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PRESENTATION TYPE: Oral