# The chemical composition of cold dark clouds

M. Agúndez[1], C. Cabezas[1], N. Marcelino[2,3], E. Roueff[4], R. Fuentetaja[1], B. Tercero[2,3], P. de Vicente[3], and J. Cernicharo[1]

[1] *Instituto de Física Fundamental, CSIC, Madrid, Spain*

[2] *Observatorio Astronómico Nacional, IGN, Madrid, Spain*

[3] *Observatorio de Yebes, IGN, Yebes, Guadalajara, Spain*

[4] *LERMA, Observatoire de Paris, PSL Research University, CNRS, Sorbonne Université, 92190 Meudon, France*

Cold dark clouds are known to host a rich variety of molecules of certain chemical complexity. In the last year, sensitive radioastronomical observations of cold dark clouds such as TMC-1 and L483 are revealing a variety of new molecules, most of which have not been anticipated by chemical models. These newly discovered molecules are revealing new intriguing aspects of the chemical composition of cold dark clouds and an even not suspected degree of chemical complexity. Moreover, for many of them the rotational spectrum has been characterized for the first time thanks to the astronomical observations since no laboratory data was available.

Among the newly discovered species, there are metastable isomers, such as $H_2NC$ [1], multiply deuterated molecules, such as doubly deuterated $CH_3CCH$ [2], various protonated molecules forms of abundant molecules, which double the number of such molecules discovered in cold dark clouds [3], and sulfur- and oxygen-containing molecules.

Of special interest is the detection of large hydrocarbons that possess low dipole moments and are therefore very abundant. Molecules like $CH_2CHCCH$, $CH_2CCHCCH$, and the radical $CH_2CCH$ are likely key agents in the synthesis of larger hydrocarbons. Cycles like c-$C_5H_6$ (cyclopentadiene), c-$C_5H_6CCH$, o-$C_6H_4$, and c-$C_9H_8$ are present with large abundances [4]. Moreover, indene is the first pure polycyclic aromatic hydrocarbon unequivocally detected in space. All these observational results are just the top of the iceberg and strongly suggest that there is a rich and abundant reservoir of aromatic molecules that are being synthesized in situ (bottom-up) in cold dark clouds like TMC-1. Elucidating the chemical pathways that lead to the formation of large aromatic organics emerges as one of the most fascinating challenges in astrochemistry.

**References**

[1] Cabezas, C., Agúndez, M., Marcelino, N., et al. 2021, A&A, 654, A45

[2] Agúndez, M., Roueff, E., Cabezas, C., et al. 2021, A&A, 649, A171

[3] Agúndez, M., Cabezas, C., Marcelino, N., et al. 2022, A&A, 659, L9

[4] Cernicharo, J., Agúndez, M., Cabezas, C., et al. 2021, A&A, 649, L15