HCCO
IN INTERSTELLAR SPACE

Divya Raj • David Nallapu • Simran Srivastava • Anushree Avasthi • Bhavya Aggarwal

Structure

The ketenyl radical(HCCO) has a planar structure with a practically linear CCO backbone and the H atom lying out of the linear axis. The radical has a $^2A''$ ground electronic state and a complex rotational structure whose N_{K_a,K_c} levels split in a fine (electronic spin-rotation interaction) and hyperfine (H nuclear spin) structure described by the quantum numbers J and F, respectively.

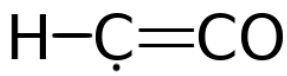

Figure 1: The Ketenyl radical, Lewis structure

Interstellar Sources of Detection

HCCO was first detected in the starless core Lupus-1A and the molecular cloud L483.[1]

Observation Techniques

The observation which led to the discovery of the molecule in interstellar space were ground based and were carried out using the IRAM 30m millimeter radio telescope, located in Veleta, Granada Province, Spain.[2]

The observations were made in selected frequency ranges from 83 to 105 GHz, which fall under the Ultra high microwave frequency range.[3]
The spectrum of Lupus-1A around 86.65 GHz showed a quartet of emission lines whose

frequencies coincide precisely with the strongest fine and hyperfine components of the $N = 4 - 3$ rotational transition of the HCCO radical[1]

Formation Mechanism

The main formation route to HCCO is the reaction between OH and C_2H. This reaction is exothermic and has an estimated rate constant of $3 \times 10^{11} cm^3 s^{-1}$.

$$OH + C_2H \rightleftharpoons HCCO + H$$

The reaction between atomic O and C_2H_2 is also exothermic in the channel yielding HCCO, although its reaction barrier is too large to be relevant at low temperatures.

$$O + C_2H_2 \rightleftharpoons HCCO + H$$

A possible precursor of HCCO is ketene. The reaction of ketene with OH is a potential source of HCCO radicals because this reaction is rapid, although it seems to have a low yield of HCCO. The HCCO radical reacts readily with neutral atoms and molecules present around it. It does so at a faster rate than its estimated rate due to the above mechanisms.Hence, A powerful formation mechanism of HCCO is needed to counterbalance the efficient depletion of this radical by reactions with neutral atoms.[1] An interesting possibility is the reactions of O atoms with C_nH radicals ($n > 3$), which are assumed to yield CO because this is the most exothermic channel, although the channel leading to HCCO is also exothermic. It is also worth noting that recent studies find that ketene can be efficiently formed in various types of ices upon irradiation with energetic electrons and ultraviolet photons (both of which can be formed in dark clouds following cosmic-ray impacts), which opens the possibility to the formation of HCCO as an intermediate.

References

[1] Marcelino Agndez, Jos Cernicharo, and Michel Gulin, *Discovery of interstellar ketenyl (HCCO), a surprisingly abundant radical*. April, 2015.

[2] Wikipedia - IRAM 30m telescope

[3] Wikipedia - Electromagnetic Spectrum