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Organic molecules in protoplanetary disks

Cécile Favre(1), Davide Fedele(1), Dmitry Semenov(2,3), Claudio Codella(1), Cecilia Ceccarelli(4), Edwin A. Bergin(5), Sergey Parfenov(6) and Franck Hersant (7)

(1) INAF-Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, I-50125, Florence, Italy (cfavre@arcetri.astro.it) (2) Max Planck Institute for Astronomy, Konigstuhl 17, 69117 Heidelberg, Germany (3) Department of Chemistry, Ludwig Maximilian University, Butenandtstr. 5-13, D-81377 Munich, Germany (4) Univ. Grenoble Alpes, CNRS, IPAG, F-38000 Grenoble, France (5) Department of Astronomy, University of Michigan, 1085 South University Avenue, Ann Arbor, Michigan 48109, USA (6) Ural Federal University, 51 Lenin Str., Ekaterinburg 620000, Russia (7) Laboratoire d'astrophysique de Bordeaux, Univ. Bordeaux, CNRS, B18N, allée Geoffroy Saint- Hilaire, 33615 Pessac, France

Abstract

Planets and comets formation occurs through the combination of dust and gas lying within the disks surrounding young stars. Among the molecules found in comets, some of them have also been detected in the interstellar medium (ISM). This leads one to ask whether these molecules were altered or formed in the protosolar nebulae or whether they are of direct ISM heritage. Consequently, understanding the formation of organic molecules, especially those of prebiotic interest, and the mechanisms that lead to their incorporation in asteroids and comets, might very well be of crucial importance for understanding the emergence of life. Thanks to recent progress in radioastronomy instrumentation for (sub-)millimeter arrays (i.e. high angular resolution and high sensitivity), such as with ALMA, new results have been obtained. I will review some notable results on the detection of organic molecules, including prebiotic molecules, towards protoplanetary disks.

1. Introduction

One of the major problem in Astrochemistry is whether the organic chemistry during the star and planet formation process is inherited by planets and small bodies of the final planetary system. And in an interstellar-Earth connection, what the key organic molecules are?

At the present time, only about twenty molecules have been detected in protoplanetary disks as shown in Table 1. Among the complex one, there are hydrocarbons, such as c-C_3H_2 (Qi et al. 2013b; Bergin et al. 2016), cyanides, HC_3N and CH_3CN (Chapillon et al. 2012; Öberg et al. 2015), and the following organic O-bearing molecules, methanol, CH_3OH (Walsh et al. 2016), and formaldehyde, H_2CO (Qi et al. 2013a; Öberg et al. 2017). The latter are important for complex organic chemistry. These finding show that the search for large organic molecules (COMS) in protoplanetary disks still remain challenging.

2. ALMA observations of COMS in TW Hya

We performed a deep search for formic acid (HCOOH), a key organic molecule for Life on Earth along with the c-C_3H_2, using the unprecedented sensitivity of the Atacama Large Millimetre/Submillimetre Array (ALMA). I will present our detections towards the protoplanetary disk surrounding the closest Solar-type young star TW Hya (Favre et al. submitted to ApJL).

3. Summary and Conclusions

Along with the detection of methanol and cyanide in the same protoplanetary disk, our study shows that complex organic chemistry is taking place in objects where planet formation occurs.

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Molecular inventory of protoplanetary disks

Atoms	
C^+, O	Meeus et al. (2012)
Ions	
HCO^+, $H^{13}CO^+$, DCO^+, N_2H^+, CH^+	Dutrey et al. (1997, 2007), van-Dishoeck et al. (2003), Thi et al. (2011), Qi et al. (2008, 2013), Öberg et al. (2015a)
Carbon reservoirs?	
CO, CO_2	Koerner & Sargent (1995), Pontoppidan et al. (2010)
Simple species	
^{13}CO, $C^{18}O$, OH, HD	Dutrey et al. (1996), Pontoppidan et al. (2010), Bergin et al. (2013), Favre et al. (2013), McClure et al. (2016)
S-bearing molecules	
CS, SO	Dutrey et al. (1997), Guilloteau et al. (2013)
N-bearing molecules	
CN, HCN, HNC, DCN	Dutrey et al. (1997), Qi et al. (2008)
Carbon chains	
CCH, C_2H_2, c-C_3H_2, HC_3N	Dutrey et al. (1997), Pontoppidan et al. (2010), Henning et al. (2010), Chapillon et al. (2012), Qi et al. (2013) Öberg et al. (2015b)
Water	
H_2O	Bergin et al. (2010), Hogerheijde et al. (2011), Podio et al. (2013)
O-bearing molecules	
H_2CO	Öberg et al. (2017)
Complex molecules	
CH_3OH, CH_3CN	Walsh et al. (2016), Öberg et al. (2015)

Figure 1: Table 1 - Molecular inventory of protoplanetary disks.

References

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