J/MNRAS/449/2438 Formamide detection with ASAI-IRAM (Lopez-Sepulcre+, 2015)

Shedding light on the formation of the pre-biotic molecule formamide with ASAI.
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<Mon. Not. R. Astron. Soc., 449, 2438-2458 (2015)>
=2015MNRAS.449.2438L (SIMBAD/NED BibCode)

ADC_Keywords: Atomic physics ; Interstellar medium ; YSOs ; Spectroscopy

Keywords: astrochemistry - methods: observational - stars: formation - ISM: abundances - ISM: molecules

Abstract:

Formamide (NH_2CHO) has been proposed as a pre-biotic precursor with a key role in the emergence of life on Earth. While this molecule has been observed in space, most of its detections correspond to high-mass star-forming regions. Motivated by this lack of investigation in the low-mass regime, we searched for formamide, as well as isocyanic acid (HNCO), in 10 low- and intermediate-mass pre-stellar and protostellar objects. The present work is part of the IRAM Large Programme ASAI (Astrochemical Surveys At IRAM), which makes use of unbiased broad-band spectral surveys at millimetre wavelengths. We detected HNCO in all the sources and NH_2CHO in five of them. We derived their abundances and analysed them together with those reported in the literature for high-mass sources. For those sources with formamide detection, we found a tight and almost linear correlation between HNCO and NH_2CHO abundances, with their ratio being roughly constant - between 3 and 10 - across 6 orders of magnitude in luminosity. This suggests the two species are chemically related. The sources without formamide detection, which are also the coldest and devoid of hot corinos, fall well off the correlation, displaying a much larger amount of HNCO relative to NH_2CHO. Our results suggest that, while HNCO can be formed in the gas-phase during the cold stages of star formation, NH_2CHO forms most efficiently on the mantles of dust grains at these temperatures, where it remains frozen until the temperature rises enough to sublimate the icy grain mantles. We propose hydrogenation of HNCO as a likely formation route leading to NH_2CHO.

Description:

Our source sample consists of 10 well-known pre-stellar and protostellar objects representing different masses and evolutionary

states, thus providing a complete view of the various types of objects encountered along the first phases of star formation.
The data presented in this work were acquired with the IRAM 30-m telescope near Pico Veleta (Spain) and consist of unbiased spectral surveys at millimetre wavelengths. These are part of the Large Programme ASAI, whose observations and data reduction procedures will be presented in detail in an article by Lefloch & Bachiller (in preparation). Briefly, we gathered the spectral data in several observing runs between 2011 and 2014 using the EMIR receivers at 3 mm (80-116 GHz), 2 mm (129-173 GHz), and 1.3 mm (200-276 GHz).

File Summary:

FileName	Lrecl	Records	Explanations
ReadMe	80	.	This file
table1.dat	103	10	Source sample and their properties
tableb1.dat	81	84	NH_2CHO transitions searched for in this study and 3σ detections
tableb2.dat	81	21	HNCO transitions searched for in this study and 3σ detections
tableb3.dat	71	2	L1544: Gaussian fits to the detected HNCO lines
tableb4.dat	71	3	TMC-1: Gaussian fits to the detected HNCO lines
tableb5.dat	71	4	B1: Gaussian fits to the detected HNCO lines
tableb6.dat	71	4	L1527: Gaussian fits to the detected HNCO lines
tableb7.dat	71	4	L1157mm: Gaussian fits to the detected HNCO lines
tableb8.dat	71	17	IRAS 4A: Gaussian fits to the detected NH_2CHO and HNCO lines
tableb9.dat	71	28	I16293: Gaussian fits to the detected NH_2CHO and HNCO lines (intensity in T^*_{ant} units)
tableb10.dat	71	32	SVS13A: Gaussian fits to the detected NH_2CHO and HNCO lines
tableb11.dat	71	10	Cep E: Gaussian fits to the detected NH_2CHO and HNCO lines
tableb12.dat	71	30	OMC-2 FIR 4: Gaussian fits to the detected NH_2CHO and HNCO lines

See also:
J/A+A/473/177 : A search for pre-biotic molecules (Wirstrom+, 2007)
J/A+A/548/A71 : Spectroscopy and ISM detection of formamide (Motiyenko+, 2012)
J/A+A/556/A57 : Transitions in OMC-2 FIR 4 in the far-IR (Kama+, 2013)
J/A+A/606/A82 : Observed chemical structure of L1544 (Spezzano+, 2017)

Byte-by-byte Description of file: table1.dat

Bytes	Format	Units	Label	Explanations
1- 7	A7	---	Survey	Survey identification (ASAI or TIMASSS)
9- 19	A11	---	Name	Source name
21- 22	I2	h	RAh	Hour of Right Ascension (J2000)
24- 25	I2	min	RAm	Minute of Right Ascension (J2000)
27- 31	F5.2	s	RAs	Second of Right Ascension (J2000)
33	A1	---	DE-	Sign of the Declination (J2000)
34- 35	I2	deg	DEd	Degree of Declination (J2000)
37- 38	I2	arcmin	DEm	Arcminute of Declination (J2000)
40- 43	F4.1	arcsec	DEs	Arcsecond of Declination (J2000)
45- 49	F5.1	km/s	Vlsr	Local Standard of Rest velocity
51- 53	I3	pc	Dist	Distance
55- 59	F5.2	Msun	Mass	Mass
61- 65	F5.1	Lsun	Lbol	? Bolometric luminosity
67- 82	A16	---	Type	Source type (1)
84- 90	A7	---	Ref	Reference(s) (2)
92-103	A12	---	FileName	File containing data for this source

Note (1): Type as follows:
PSC = Pre-stellar core;
HC = Hot corino;
WCCC = Warm carbon-chain chemistry;
IM = Intermediate-mass.

Note (2): Reference as follows:
1 = Elias (1978ApJ...224..857E);
2 = Evans et al. (2001ApJ...557..193E);
3 = Shirley et al. (2000ApJS..131..249S);
4 = Toth et al. (2004A&A...420..533T);
5 = Hirano et al. (1999sf99..R....181H);
6 = Marcelino et al. (2005ApJ...620..308M);
7 = Kristensen et al. (2012A&A...542A...8K);
8 = Karska et al. (2013A&A...552A.141K);
9 = Hirota et al. (2008PASJ...60...37H);
10 = Chen, Launhardt & Henning (2009ApJ...691.1729C);
11 = Crimier et al. (2009A&A...506.1229C);
12 = Furlan et al. (2014ApJ...786....6L);
13 = Crimier et al. (2010A&A...516A.102C);
14 = Loinard et al. (2008ApJ...675L..29L);
15 = Correia, Griffin & Saraceno (2004A&A...418..607C).

Byte-by-byte Description of file: tableb1.dat tableb2.dat

Bytes	Format	Units	Label	Explanations
1- 17	A17	---	Trans	Transition
19- 28	F10.3	MHz	nu	Frequency of the transition ν
30- 34	F5.1	K	Eu	Upper level energy
36- 41	F6.2	10-5/s	Aul	Transition rate
43- 44	I2	arcsec	thetab	[9/30] Telescope beam size θ_b
46- 47	A2	---	OMC-2	[Y*NB-] 3σ detection for OMC-2 FIR 4 (1)
49- 50	A2	---	CepE	[Y*N-] 3σ detection for CepE (1)
52- 53	A2	---	SVS13A	[Y*NB-] 3σ detection for SVS13A (1)
55- 56	A2	---	IRAS4A	[Y*bNB] 3σ detection for IRAS4A (1)
58- 59	A2	---	I16293	[Y*bcNB] 3σ detection for I16293 (1)
61	A1	---	L1157	[YN] 3σ detection for L1157 (1)
63	A1	---	L1527	[YN] 3σ detection for L1527 (1)
65	A1	---	B1	[YN-] 3σ detection for B1 (1)
67	A1	---	L1544	[YN-] 3σ detection for L1544 (1)
69	A1	---	TMC-1	[YN-] 3σ detection for TMC-1 (1)
71- 81	A11	---	Blend	Blended line identifier (2)

Note (1): Detection as follows:
- Y = Detected above T_{mb}=3σ;
- Y* = Weakly detected (S/N~2-3; see Section 4.1);
- Yb = Detected but with an anomalously high flux (maybe blended): removed from analysis;
- Yc = Blended with an unidentified feature: removed from analysis;
- N = Undetected;
- B = Possibly detected but blended;
- \- = Not observed.

Note (2): Blended line in tableb2 : CH_3OH at 241.774 GHz.

Byte-by-byte Description of file: tableb[3456789].dat tableb1[012].dat

Bytes	Format	Units	Label	Explanations
1	A1	---	Mol	[NH] Molecule identification (1)
3- 19	A17	---	Trans	Transition
20- 21	A2	---	n_Trans	[w *] Note on Trans (2)
23- 32	F10.3	MHz	nu	Frequency of the transition ν

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  34- 37  F4.1  mK         rms     rms value
  39- 43  F5.1  mK         Tpeak   Peak temperature
  45- 46  I2    mK       e_Tpeak   Uncertainty in Tpeak
  48- 52  F5.1  km/s       Vlsr    Local Standard of Rest velocity
  54- 55  I2    km/s       e_Vlsr  Unceraintry in Vlsr
  57- 59  F3.1  km/s       DeltaV  Velocity difference
  61- 62  I2    km/s     e_DeltaV  Uncertainty in DeltaV
  64- 67  I4    mK.km/s    TmbdV   Line flux for the source
  69- 71  I3    mK.km/s  e_TmbdV   Uncertainty in TmbdV
```

Note (1): Molecule as follows:
  N = NH_2CHO;
  H = HNCO.
Note (2): Note as follows:
  w = Transition weakly detected (see Table B1) but included in the analysis for completeness;
  * = Transition affected by emission at OFF position: lower limit point in the rotational diagram.

History:
  From electronic version of the journal

(End) Tiphaine Pouvreau [CDS] 06-Dec-2017

*The document above follows the rules of the Standard Description for Astronomical Catalogues; from this documentation it is possible to generate **f77** program to load files into arrays or line by line*