CAN CHEMICAL MAPS INDICATE INTERSTELLAR FORMATION OF METHYL FORMATE?

Jalisa Taylor, Ashley Barham, Jessica Jones
July 30, 2010
How do organic molecules form in Astronomical environments?

Can the tools of astronomy be Used to test fundamental Theories of chemistry?
## What is the Current Chemical Inventory of Space?

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What do we need? Array and Single Dish Telescopes

Arrays
- Gives finer detail.
- Shows contour maps of chemical concentrations.
- Contour maps of difference molecules may be different in the same region.

Single dish telescope
- Has a wide frequency coverage which collects an abundance of spectra.
ARRAY'S
At GBT beam size ($\Theta$) ~ $720''/\nu$ (GHz)

Example: At 10 GHz, $\Theta=72''$
Use the array data to determine if methanol, formic acid and methyl formate are in the same region of space.

Orion KL (the region we are studying)
WHERE DO WE BEGIN?

Ashley Barham
OBJECTIVES

- Why Methyl Formate?
- Hypothesis
- Cis- and trans-
- Experiment
- Next step
The molecule in question: **Methyl Formate** (HCOOCH$_3$)  

**Why Methyl Formate?**

There are many mechanisms of forming methyl formate in an interstellar medium aspect:
- Grain Chemistry
- Fisher Esterification
- Protonated Formic Acid

**Methyl Transfer Reaction**
Methyl Transfer Reaction:

\[ [\text{CH}_3\text{OH}_2]^+ + \text{HCOOH} \rightarrow \text{HC(OH}^+\text{)OCH}_3 + \text{H}_2\text{O} \]

The outcome of the reaction
- Where methyl formate is at its highest concentration, formic acid’s peak of concentration should be absent.
- Two different geometries of methyl formate should be formed: cis- and trans-

This reaction produces protonated methyl formate. But, there are well known interstellar processes such as electron recombination or proton transfer to remove the + charge.
CIS- AND TRANS-

$\text{Cis barrier: 10.99 kJ/mol}$

$\text{Cis-} [\text{HC(OH)OCH}_3]^+ + \text{H}_2\text{O}$

$\text{Trans-} [\text{HC(OH)OCH}_3]^+ + \text{H}_2\text{O}$

$\text{Trans barrier: -8.24 kJ/mol}$

$\text{CH}_3\text{OH} + [\text{HCOOH}_2]^+$

$\text{MP2/6-31G (d,p)}$
The use of Arrays can give us the maps of the distributions of the molecules.
METHYL FORMATE VS. FORMIC ACID

Formic Acid in the Compact Ridge of Orion

Formic Acid and Methyl Formate overlapped
Low mass star forming region IRAS 16293
We have chemical maps toward Orion and IRAS 16293. 
Now we need to locate cis- and trans-geometries of methyl formate toward Orion.
DATA TAKEN FROM SGRB2N AND ORION
Methyl formate in SGRB2N
- Cis- and Trans-

Proposal

Research we have done on the GBT in the Orion region
VLA interferometer located in Socorro, New Mexico

Taken using BIMA

Contour Maps:

Bold-Formic Acid
Thin-Methyl Fomate
Lab Data

Line of absorption at the GBT of trans methyl formate
- Molecule absorbs energy

2-1 $trans$-methyl formate A

Frequency (MHz)
Intensity

UVA Broadband Spectrum Methyl Formate
GBT PRIMOS
Different frequency

Graph showing Absorption Lines with two traces: UVA Broadband Spectrum Methyl Formate and GBT PRIMOS. The graph highlights a peak labeled 2-1 trans-methyl formate E.
NEW MAPPING DATA WITH THE EVLA IN ORION:

WHITE Contours - CH3OH
BLUE Contours - CH3OCHO
Bright Yellow and Orange - 26 GHz continuum
METHYL FORMATE AND METHANOL WITH THE EVLA IN ORION:

Single Point Profile

CH₃OH

CH₃OCHO

frequency (TOPO) (GHz)
Purpose of getting time on the GBT:

• We have chemical maps that support the first aspect of our hypothesis.
  • Methyl Formate’s peak and Formic Acid’s peak
• What we need is the detection of Cis- and Trans-
Approved!!
METHANOL IN ORION:

2010-07-23  Int: 00 39 39.5  Faky: 9.93563 GHz  IF: 3  Tcal: 1.25
Robin Pulliam  LST: +03 09 52.6  BW: 200.0000 MHz  AGET10B_048_01 OffOn

05 35 14.31 -05 22 40.9

OrionCR

Az: 134.0  El: 34.8  HA: -2.42

CH3OH

9(-1,9)-8(-2,7)
TRANS METHYL FORMATE IN ORION:

Scan 7  V: 9.0 RADL-LSR  F0: 9.20800 GHz  Pol: 1  Tsys: 27.38
2010-07-23  Int: 00 33 05.4  Fsky: 9.12463 GHz  IF: 1  Teal: 1.93
Robin Pulliam  LST: 03 09 52.6  BW: 200.0000 MHz  AGBT10B_048_01 OffOn
05 35 14.31 -05 22 40.9

Orion CR

Az: 134.0  El: 34.8  HA: -2.42

Antenna Temperature (K)

H(112) Beta

He(112) Beta

t-CH3OCHO
1(1,0) - 0(0,0) A

LSR Frequency (MHz)  AV=8.0000 km/s RADIO

Tue Jul 27 11:15:05 2010
More than half time lost because of mechanical issues with the receiver turret on telescope

Signal to noise ratio wasn’t good enough (~50 mK) so more time is clearly needed.
CONCLUSION

- We have the Chemical Maps of Methanol, Formic Acid, and Methyl Formate in the Orion KL region, and in IRAS 16293
- We have detections of cis- and trans- in Sagittarius B2 North
- We have detection of Methanol in the Orion Compact Ridge using the Green Bank Telescope
- With more integration time we hope to find the geometries of cis- and trans-
REFERENCES


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