SiO and CH_3CCH abundances and dust emission in high-mass star-forming cores

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Abstract

We present the results of SiO and CH_3CCH spectral line and 1.2 mm dust continuum observations of 15 high-mass star-forming cores made with the SEST. We investigate the dependence of the fractional SiO and CH_3CCH abundances on physical conditions to provide constraints on the chemistry models of the formation of these molecules. The poster is based on article by Miettinen et al. [6].

The Sample

Source	$\alpha_{2000.0}$ [h:m:s]	$\delta_{2000.0}$ [°:′:″]	l, b [°]	d [kpc]
IRAS 12326-6245	12:35:34.1	-63:02:28	301.13-0.22	4.4[a]
G326.64+0.61	15:44:32.3	-54:05:54	326.64+0.61	2.7
OH328.81+0.63	15:55:47.3	-52:43:08	328.81+0.63	2.9
IRAS 15566-5304	16:00:30.7	-53:12:34	329.03-0.20	3.0
G330.95-0.19	16:09:52.2	-51:55:20	330.95-0.19	6.1
G345.01+1.8N	16:56:47.2	-40:14:09	345.01+1.80	1.7
IRAS 16562-3959	16:59:41.9	-40:03:42	345.49+1.47	1.6
G345.00-0.23	17:05:11.7	-41:29:11	345.00-0.23	2.9
NGC 6334 FIR-V	17:19:55.9	-35:57:45	351.16+0.70	1.7[b]
NGC 6334F	17:20:53.5	-35:47:01	351.42+0.65	1.7[b]
G351.77-0.54	17:26:42.6	-36:09:17	351.77-0.54	0.7
G353.41-0.36	17:30:26.0	-34:41:57	353.41-0.36	3.5
W28 A2(2)	18:00:30.4	-24:04:00	5.88-0.39	2.7
W31 (2)	18:10:28.7	-19:55:50	10.62-0.38	3.1[c]
W33 CONT	18:14:13.6	-17:55:25	12.81-0.20	3.7

Observations

The spectral line observations (^{28}SiO and ^{29}SiO v=0, J=2–1 and v=0, J=3–2, and CH_3CCH $J=5_K–4_K$ and $J=6_K–5_K$) were made during four observing runs from 1995 to 2003 with the SEST. The CH_3CCH observations were the last spectral line observations made with the SEST. The 1.2 mm dust continuum observations were carried out in June 2003 with the SIMBA bolometer at the SEST.

Observational results

The obtained SIMBA maps of three of our sources, NGC 6334, G326.64+0.61, and W33 are presented in Fig. 1. The obtained SiO and CH_3CCH spectra of NGC 6334 FIR-V are presented in Fig. 2. The SiO lines are nearly Gaussian in the central part and have broad, asymmetric wings. Four K-components (K=0,1,2,3) of the CH_3CCH transitions were detected towards all sources. The rotational temperatures and the CH_3CCH column densities were derived by means of the population diagram method. Rotational diagram for NGC 6334 FIR-V is shown in Fig. 3.

The goodness of the fit substantiates the assumption that the gas is in LTE with $T_{rot} \approx T_{kin}$.

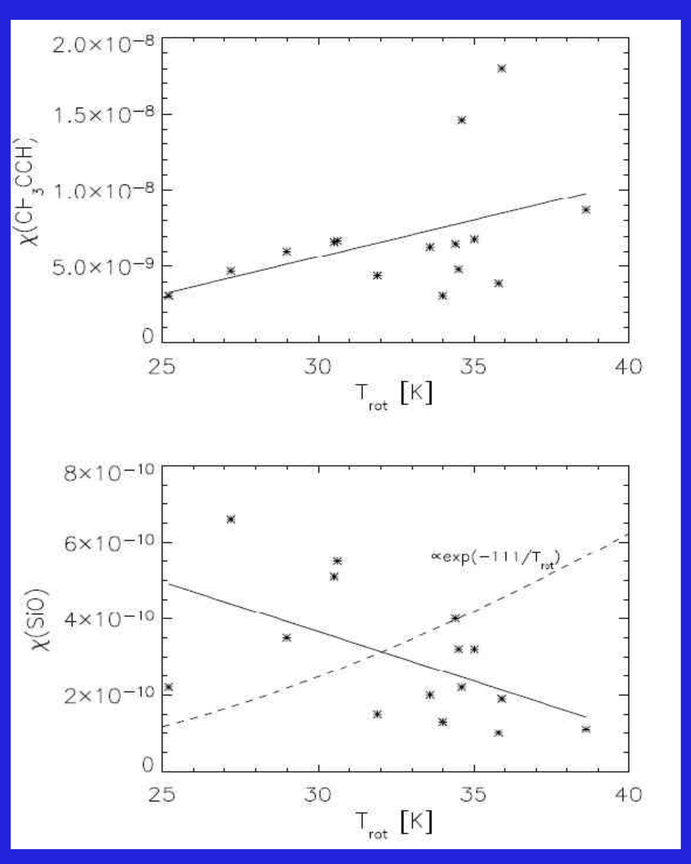


Fig. 4. Fractional CH_3CCH and SiO abundances as functions of the rotational temperatures derived from CH_3CCH. The dashed line in the bottom panel represents a change in the fractional SiO abundance proportional to exp(-111 K/ T) as suggested by Langer and Glassgold [4].

References

[1] Askne, J., Höglund, B., Hjalmarson, Å., & Irwine, W. M. 1984, A&A, 130, 311
[2] Bergin, E. A., Goldsmith, P. F., Snell, R. L., & Ungerechts, H. 1994, ApJ, 431, 674
[3] Churchwell, E., Povich, M. S., Allen, D., et al. 2006, ApJ, 649, 759
[4] Langer, W. D., and Glassgold, A. E. 1990, ApJ, 352, 123
[5] Martín-Pintado, J., Bachiller, R., & Fuente, A. 1992, A&A, 254, 315
[6] Miettinen, O., Harju, J., Haikala, L. K., and Pomrén, C. 2006, A&A, 460, 721
[7] Schilke, P., Walmsley, C. M., Pineau des Forêts, G., & Flower, D. R. 1997, A&A, 321, 293

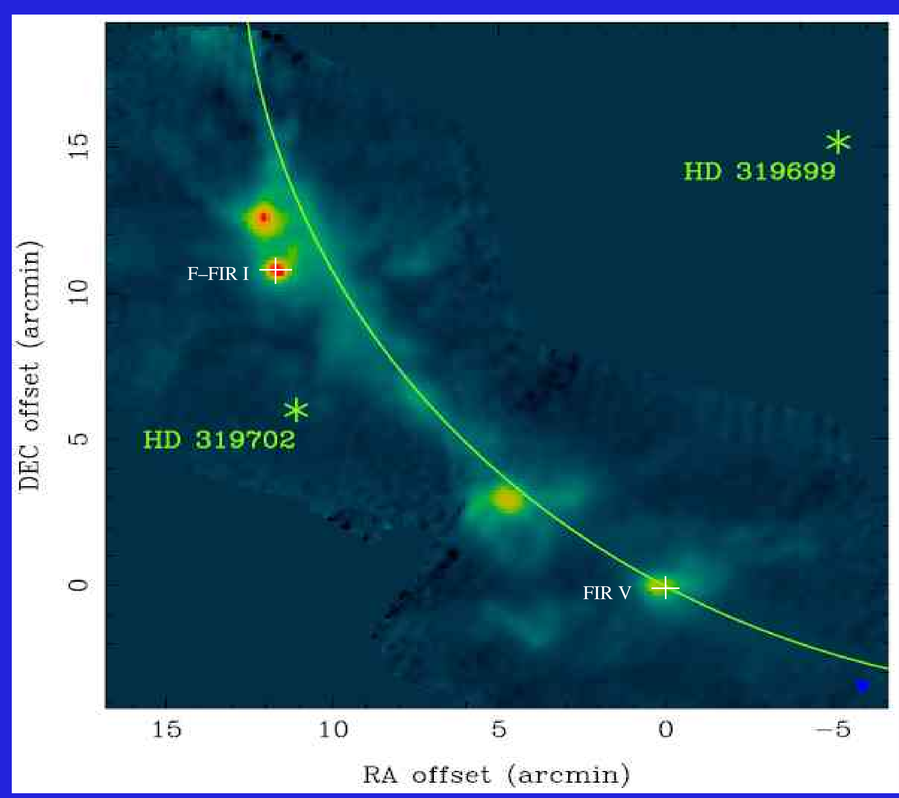
Introduction

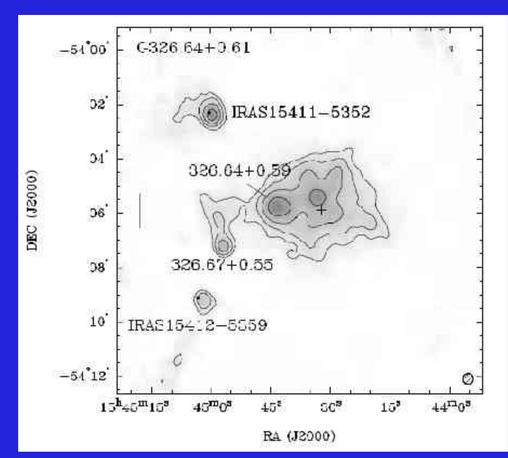
SiO is believed to trace exclusively shocked gas as its spectral lines have wings and are often shifted relative to the emission of the ambient gas (see, e.g., [5], [7]). Our current understanding is that SiO is evaporated from the dust grains when the shock velocity is $\gtrsim$ 20 km s^{-1}.

In dense and warm GMC cores, SiO seems to present also in the quiescent gas component.

The present observational evidence is insufficient to determine the cause of the presence of quiescent SiO. To resolve this we determine fractional SiO abundances and kinetic temperatures in a representative sample of GMC cores.

The rotational temperature derived from a series of $J_K \rightarrow (J\text{-}1)_K$ rotational lines of CH_3CCH is considered a good estimate of the gas kinetic temperature in molecular clouds (e.g., [1], [2]).





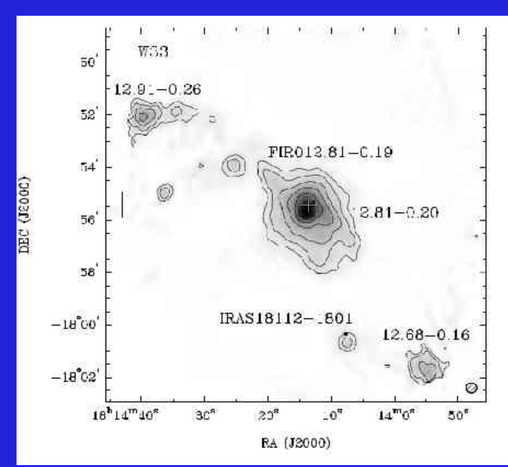
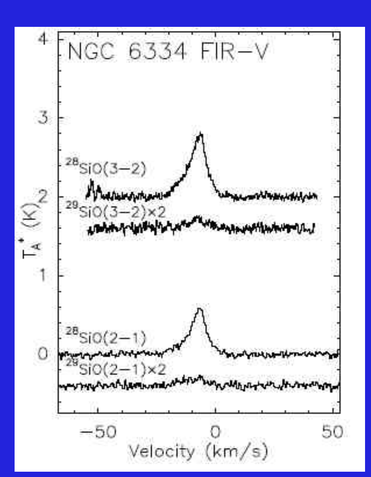


Fig. 1. The SIMBA dust continuum maps of NGC 6334, G326.64+0.61, and W33. The star-forming ridge in the region of NGC 6334 seems to follow an arc of a circle of radius 13 pc and star formation could be triggered by the expansion of a bubble (see, e.g., [3]). The target positions of the line observations are denoted with crosses.



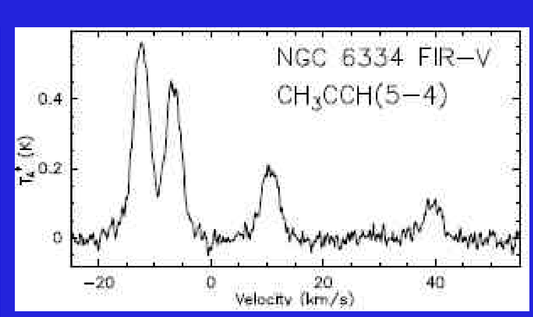


Fig. 2. SiO and CH_3CCH spectra towards NGC 6334 FIR-V.

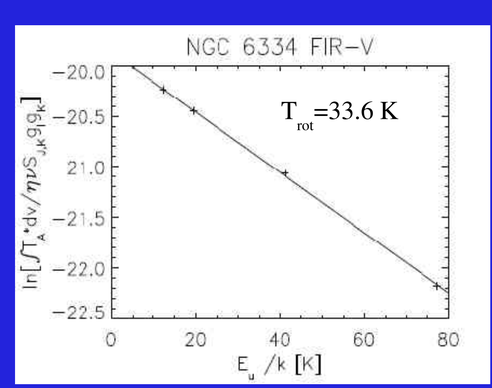


Fig. 3. Boltzmann plot of the CH_3CCH spectrum shown in Fig. 2.

Core properties

- The sample represents typical GMC cores with the following average properties: $\langle T_{kin} \rangle$ = 33 K, $\langle n(H_2) \rangle = 4.5 \cdot 10^6$ cm^{-3}, $\langle M_{cont} \rangle$ = 1800 M$_\odot$, $\langle R \rangle$ = 0.2 pc
- The virial masses calulated using the velocity dispersions and kinetic temperatures from the CH_3CCH data indicates that most of the cores studied here are gravitationally bound ($M_{cont} \gtrsim M_{vir}$)
- The fractional SiO abundances determined from the velocity range with detectable CH_3CCH emission were found to be ~1– 7·10^{-10}
- CH_3CCH abundances were found to be 3–18·10^{-9}

SiO and CH_3CCH abundances

- The 1.2 mm dust emission is likely to be dominated by the cool (T ~ 30 K) envelopes, although it has a contribution from hot cores (T > 100 K) around newly born massive stars
- While it can be assumed that the CH_3CCH lines and 1.2 mm dust continuum emission trace to a large part the same material, for dust and SiO this is not clear
- The SiO abundances seem to decrease slightly when the temperature rises (Fig. 4, bottom panel)
- A possible explanation for the SiO decrease is that warmer cores represent more evolved objects where highly energetic protostellar outflows releasing SiO in the gas phase are less frequent; this together with rapid post-shock processing have lead to a diminished SiO abundance
- We suggest that the high CH_3CCH abundance and its possible increase when the clouds become warmer (Fig. 4, top panel) is related to the intensified desorption of the precursor molecule from the icy mantles of dust grains

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