

# Spectral Lines of Carbon Chain Molecules in a Star Forming Region L1527 between 29 and 90 GHz

M. Araki,<sup>1</sup> N. Koshikawa,<sup>1</sup> H. Yamabe,<sup>1</sup> H. Umeki,<sup>1</sup> K. Tsukiyama,<sup>1</sup> S. Takano,<sup>2</sup> N. Kuze<sup>3</sup>

<sup>1</sup> *Department of Chemistry, Faculty of Science Division I, Tokyo University of Science, 1-3 Kagurazaka, Shinjuku-ku, Tokyo, 162-8601, Japan*

<sup>2</sup> *Nobeyama Radio Observatory and Graduate University for Advanced Studies, Minamimaki, Minamisaku, Nagano 384-1305, Japan*

<sup>3</sup> *Department of Chemistry, Faculty of Science and Technology, Sophia University, 7-1 Kioicho, Chiyoda-ku, Tokyo 102-8554, Japan*

We have studied molecular spectral lines of carbon chain molecules in a star forming region L1527 between 29 and 90 GHz by using the 45m telescope of the Nobeyama Radio Observatory (NRO). H<sub>2</sub>CCO, HCCCHO, SO and isotopic species of HCN and HC<sub>3</sub>N have been detected for the first time in L1527.

Using integrated intensities of the detected rotational lines of  $J_{Ka,Kc} = 4_{0,4}-3_{0,3}$ ,  $4_{1,4}-3_{1,3}$  and  $4_{1,3}-3_{1,2}$  of H<sub>2</sub>CCO, column densities of ortho and para H<sub>2</sub>CCO were estimated to be  $3.8 \times 10^{12}$  and  $2.0 \times 10^{12}$  cm<sup>-2</sup>, respectively, with an assumption of an excitation temperature of 12.3 K [1a]. These values give an ortho to para ratio of 1.8(-0.1, +0.7) which is less than the ortho to para ratio of 3.0 at the high temperature limit. The small ratio might suggest that H<sub>2</sub>CCO in L1527 comes off from the grain surfaces.

Column densities of HC<sup>13</sup>CCN and HCC<sup>13</sup>CN were obtained based on the assumption of the excitation temperature of 12.3 K [1a] as shown in Table 1. Isotopic ratios, [Normal Species]/[<sup>13</sup>C Species], were derived from a comparison with the reported column density of the normal species HC<sub>3</sub>N [1b]. Since the isotopic ratios in L1527 were similar to those in TMC-1 [2], the chemical reaction producing HC<sub>3</sub>N in L1527 can be similar to those suggested in TMC-1 as follows [2]:

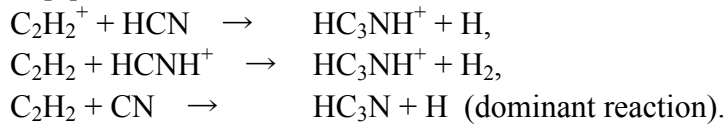


Table 1: Column densities and isotopic ratios of HC<sub>3</sub>N in TMC-1 and L1527

Isotopic Species	Column Density(cm <sup>-2</sup> )	[Normal Species]/[ <sup>13</sup> C Species]
TMC-1 [2]		
H <sup>13</sup> CCCN	$(2.0 \pm 0.2) \times 10^{12}$	79 ± 11
HC <sup>13</sup> CCN	$(2.1 \pm 0.2) \times 10^{12}$	75 ± 10
HCC <sup>13</sup> CN	$(2.9 \pm 0.3) \times 10^{12}$	55 ± 7
L1527		
H <sup>13</sup> CCCN	-	-
HC <sup>13</sup> CCN	$3.3 \times 10^{11}$	80 ± 6
HCC <sup>13</sup> CN	$5.8 \times 10^{11}$	50 ± 4

## References

- [1] (a) Sakai *et al.*, *ApJ*, **672**, 371 (2008). (b) Sakai *et al.*, *ApJ*, **702**, 1025 (2009).  
 [2] Takano *et al.*, *A&A*, **329**, 1156 (1998).