Carbon Isotope and Isotopomer Fractionation in Cold Dense Cloud Cores

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^{13}C should be useful to investigate chemistry of carbon bearing species. Recent observations in TMC-1 indicated that the molecular abundances of carbon isotopomers are different. Takano et al. (1998) observed HC_3N and found HCC^{13}CN is more abundant than HC^{13}CCN and H^{13}CCCN, which indicates three carbon atoms are not equivalent in HC_3N. Sakai et al. (2007; 2010) reported the abundance ratios of C^{13}CS/^{13}CCS = 4.2 and CCH/^{13}CCH = 1.6. Again, these results indicate two carbon atoms are not equivalent in CCS and CCH. They pointed out there are two possible processes to cause these fractionation: (i) the formation path ways of the species and (ii) the exchange of the ^{13}C position after formation of molecules by isotopomer-exchange reactions.

We construct the gas-grain chemical network model which includes carbon isotopes (^{12}C and ^{13}C). Temporal variations of molecular abundances, the carbon isotope ratios (^{12}CX/^{13}CX) and the isotopomer ratios (^{12}C^{13}CX/^{13}C^{12}CX) of CCH and CCS in cold dense cloud cores are investigated by numerical calculations.

We reproduce the observed C^{13}CH/^{13}CCH ratio in TMC-1; isotopomer-exchange reaction, ^{13}CCH + H -> C^{13}CH + H. However, the C^{13}CS/^{13}CCS ratio is lower than observed in TMC-1. We propose the isotopomer-exchange reaction, ^{13}CCS + H -> C^{13}CS + H + 15K. In the model with this reaction, we reproduce the observed C^{13}CS/^{13}CCS, CCS/C^{13}CS and CCS/^{13}CCS ratio simultaneously.

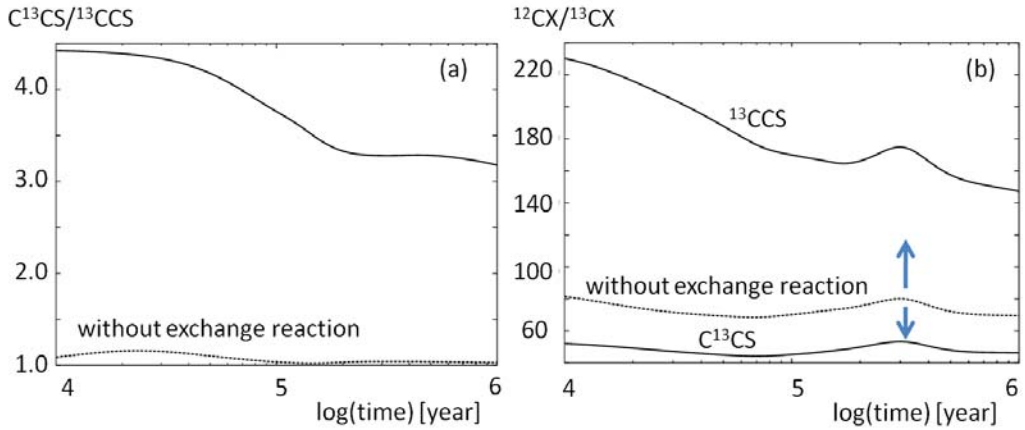

Figure 1: Temporal variation of (a) isotopomer ratios: the C^{13}CS/^{13}CCS ratio and (b) isotope ratios of CCS: the CCS/^{13}CCS and CCS/C^{13}CS ratios. Solid lines show ratios in the model with the reaction, ^{13}CCS + H -> C^{13}CS + H + 15K. Dashed line shows the isotope ratio of CCS in the model without the reaction. The density is $n_H = 10^5$ cm^{-3}.

References

[1] Takano, S. et al. 1998, A&A, 329, 1156.
[2] Sakai, N., Ikeda, M. & Morita, M., et al. 2007, ApJ, 663, 1174.
[3] Sakai, N., Saruwatari, O., Sakai, T., Takano, S., & Yamamoto, S. 2010, A&A, 512, 10.