Cyanopolyyne Chemistry in High-Mass Star-Forming Regions

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Cyanopolyynes ($HC_{2n+1}N$; n=1, 2, 3, ...) are one of the representative carbon-chain series. In general, HC_3N, the shortest member of cyanopolyynes, is detected from starless cores and star-forming cores, while longer cyanopolyynes (i.e., HC_5N and HC_7N) are abundant in starless cores and deficient in star-forming cores.

The chemical composition around young stellar objects (YSOs) is key to the initial chemical condition and/or star formation processes. Figure 1 shows the chemical diversity around YSOs. In low-mass star-forming regions, chemically two types have been found: hot corino (complex organic molecules (COMs)-rich) and warm carbon chain chemistry (WCCC; carbon-chain-rich). The different starless core phases are considered to be a factor to bring the difference between hot corino and WCCC; long and short starless core phases lead hot corino and WCCC, respectively [1]. In high-mass star-forming regions, hot core sources, where COMs are abundant as well as hot corino, have been found, while no counterpart of WCCC source has been confirmed.

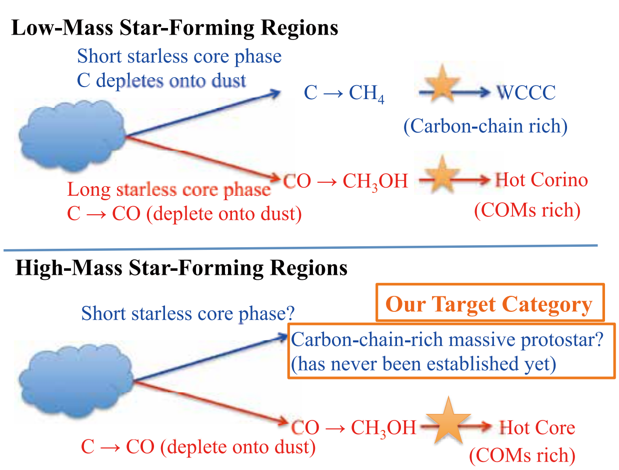

Figure 1: Chemical diversity around YSOs.

We carried out observations of long cyanopolyynes toward four massive young stellar objects (MYSOs; G10.30−0.15, G12.89+0.49, G16.86−2.16, and G28.28−0.36) associated with the 6.7 GHz CH_3OH masers with the Nobeyama 45-m radio telescope and the Green Bank 100-m telescope (GBT) [2]. HC_5N has been detected from all of the four sources and HC_7N has been detected from the three sources except for G10.30−0.15 with the GBT. We also detected the high excitation energy (E_u/k ~ 100 K) lines of HC_5N from the three sources, except for G10.30−0.15, with the Nobeyama 45-m radio telescope. Such high excitation energy lines cannot be detected if HC_5N exists in cold molecular clouds. Therefore, the detection of these lines means that HC_5N exists in the warm gas around MYSOs. We found a possibility of the chemical diversity among MYSOs; G28.28−0.36 shows the highest HC_5N abundance without a thermal CH_3OH line observed with the GBT, while G12.89+0.49 shows the lowest HC_5N abundance with a strong thermal CH_3OH emission line. From the results, G28.28−0.36 seems to be a good candidate of a counterpart of WCCC source in high-mass star-forming regions.

In low-mass star-forming regions, cyanopolyynes are known to be good chemical evolutional indicators (e.g. [3]). On the other hand, the chemical evolution of cyanopolyynes in high-mass star-forming regions was not clear. We carried out survey observations of HC_3N and HC_5N in the 45 GHz band toward 17 high-mass starless cores (HMSCs) [4] and 35 high-mass protostellar objects (HMPOs) [5] with the Nobeyama 45-m radio telescope [6]. We have detected HC_3N from 15 HMSCs and 28 HMPOs, and HC_5N from 5 HMSCs and 14 HMPOs, respectively. From the Kolmogorov-Smirnov test, the HC_3N column density increases from HMSCs to HMPOs, which may imply that HC_3N is newly formed at HMPO stage. In addition, the HC_3N column density tends to decrease with increasing the luminosity-to-mass ratio, which is a physical evolutional indicator. This suggests that HC_3N is destroyed by stellar activities (e.g., UV radiation).

Our studies are on-going projects. Current our conclusion is that cyanopolyynes are good candidates of chemical evolutionary indicators in high-mass star-forming regions.

References

[1] Sakai, N., Yamamoto, S.: 2013, *Chem. Rev.*, **113**, 8981.
[2] Taniguchi, K., et al.: 2017, *ApJ*, **844**, 68.
[3] Suzuki, H., et al.: 1992, *ApJ*, **392**, 551.
[4] Sridharan, T. K., et al.: 2005, *ApJL*, **634**, L57.
[5] Sridharan, T. K., et al.: 2002, *ApJ*, **566**, 931.
[6] Taniguchi, K., et al.: 2018, *ApJ*, **854**, 133.