A Search for Chemical Evolutional Indicators in High-Mass Star-Forming Regions

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Carbon-chain molecules have been known as good chemical evolutional indicators in low-mass star-forming regions (e.g., [1],[2]). They are abundant in young starless cores and decrease in star-forming cores. On the other hand, chemical evolutional indicators have not been clearly established in high-mass star-forming regions, nevertheless there were many attempts (e.g., [3]).

We have carried out survey observations of HC_3N, HC_5N, CCS, *cyclic*-C_3H_2, and N_2H^+ toward 17 high-mass starless cores (HMSCs)[4] and 28 high-mass protostellar objects (HMPOs)[5] using the Nobeyama 45-m radio telescope. The main purpose of this survey project is to find good chemical evolutional indicators, which enable us to find the very early stage of high-mass protostars containing the initial conditions of massive star formation. We investigated several molecular combinations and found that the $N(N_2H^+)/N(HC_3N)$ ratio is a good candidate for chemical evolutional indicators in high-mass star-forming regions. Figure 1 (a) shows the relationship between the column density ratio of $N(N_2H^+)/N(HC_3N)$ and the HC_3N column density in HMSCs and HMPOs. The ratio decreases from HMSC to HMPO. Surprisingly, this tendency is opposite to that in low-mass star-forming regions as shown Figure 1 (b). One possible explanation for the difference between high-mass and low-mass star-forming regions is the higher temperature in high-mass star-forming regions; CH_4 and/or C_2H_2 evaporated from grain mantles form HC_3N, whereas N_2H^+ is destroyed by CO molecules liberated from dust.

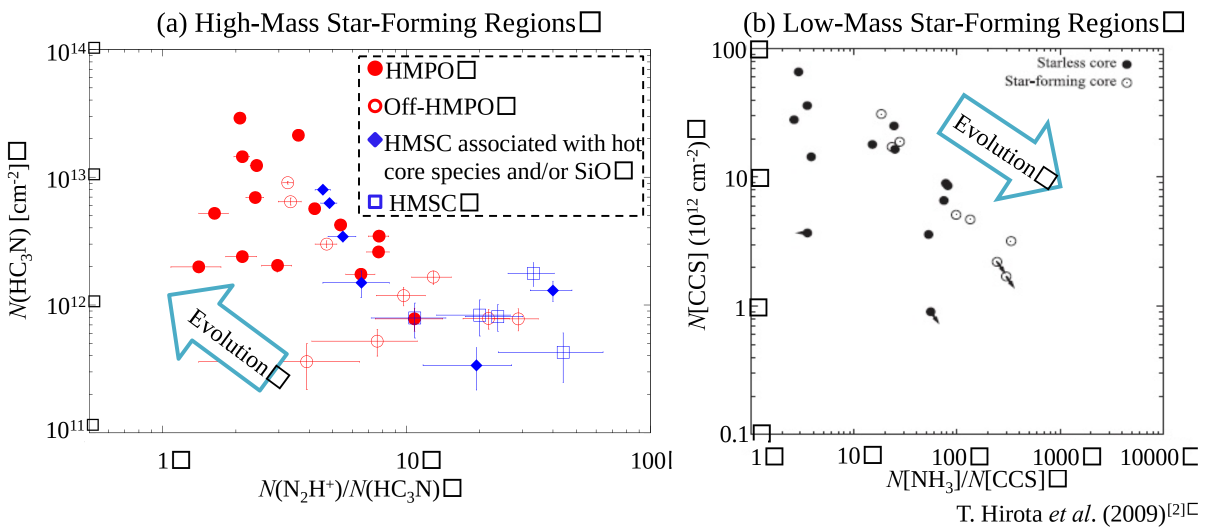

Figure 1: Chemical evolutional indicators in (a) high-mass star-forming regions and (b) low-mass star-forming regions. (a) Off-HMPO means that the center positions of the telescope were off from the 1.2 mm dust continuum emission peaks.

In addition, HMSCs, which were classified based on the mid-infrared (8.3 μm) observations, associated with CH_3OH, CH_3CN, and/or SiO are plotted between HMSCs and HMPOs. This suggests that we can find very-early-stage high-mass protostars embedded within dense cores, using the $N(N_2H^+)/N(HC_3N)$ ratio.

We compare the detection rates of carbon-chain molecules between HMPOs and low-mass protostars[6]. The detection rates of cyanopolyynes in HMPOs (93% for HC_3N and 50% for HC_5N[7]) are higher than those in low-mass protostars (75% and 31%, respectively), whereas CCS has been more frequently detected in low-mass protostars (88%) compared to HMPOs (46%). These results imply that carbon-chain chemistry around protostars is different between high-mass and low-mass protostars.

References

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