

## CO gas depletion and formation of organic molecules in protoplanetary disks

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Protoplanetary disks are the natal place of planets and ALMA observations are now revealing the physical and chemical structure of planet forming regions in the disks. Understanding chemical components of gas, dust and ice in the disks is essential to investigate the origins of materials in the plants. In the talk, I shall report our recent ALMA Band 7 observations of CO isotopologue lines from the protoplanetary disk around TW Hya. The result shows a significant decrement in CO gas throughout the disk even inside the CO snowline, indicating freeze-out of gas-phase CO onto grain surfaces and possible subsequent surface reactions to form larger molecules. Complex organic molecules could be efficiently produced in the observed CO gas depleted regions. Actually, methanol has been detected towards the TW Hya, whose abundance relative to water is consistent with that of comets in our Solar system.

In addition, we performed model calculations of formation of complex organic molecules in protoplanetary disks, taking into account of thermal reactions including acid-based reactions in ice based on laboratory experiments. The result suggests relatively effective formation of some nitrogen-bearing species, such as CH<sub>3</sub>NH<sub>2</sub>, NH<sub>2</sub>CHO, CH<sub>3</sub>NHCOOH, NH<sub>2</sub>COOH.

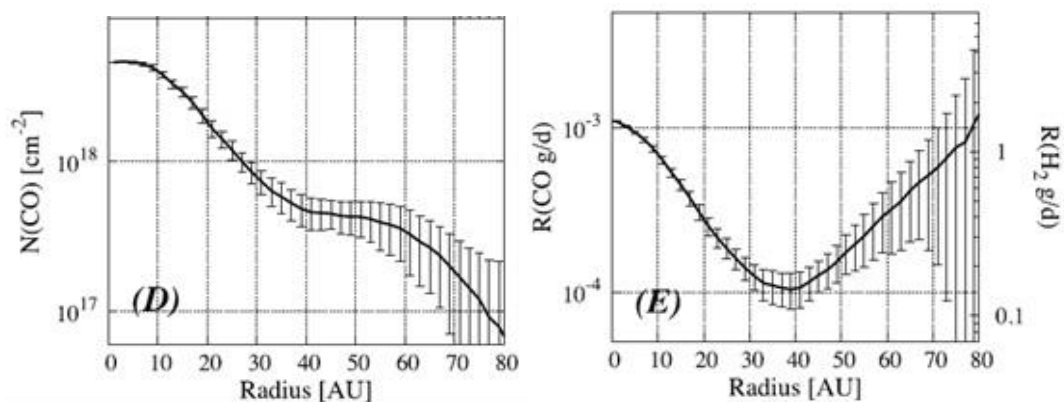


Figure 1: The CO gas column density profile (*left*) and the CO gas-to-dust ratio profile (*right*) in the protoplanetary disk around TW Hya, derived from our ALMA observations..

### References

- [1] H. Nomura, T. Tsukagohi, K. Ryohei et al. 2016, ApJL, 819, L7
- [2] C. Walsh, R. Loomis, K. Oberg et al. 2016, ApJL 823, L10.