How to understand the origin of interstellar- “complex” organic molecules?

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Planet formation is a natural consequence of the star formation process, and there is an incredible variety of planetary systems, which are significantly different from the Solar System. Recent ALMA observations have revealed chemistry in planet-forming regions. Various “complex” organic molecules (COMs) are found in protoplanetary-disk forming regions, and their abundances vary significantly among objects [e.g. 1,2,3]. This indicates that the Solar System may not have been common in terms of its initial chemistry, which invokes the discussion on the rarity of our existence. Progress of the Solar System exploration, including the recent successful return of the Hayabusa2 spacecraft, makes it possible to analyse pristine Solar System materials directly. The combination of such analysis with high-sensitivity observations of planet-forming regions may allow us to locate our Solar System among the diversity. To tackle these questions, we must revisit fundamental astrochemical processes. In the past decades, the astrochemical studies focused on chemistry under extremely low temperature (~10 K) and density conditions (10^2-10^6 cm^{-3}), where only barrierless exothermic reactions proceed efficiently. During the planetary system formation, on the other hand, the physical condition changes dynamically resulting in dynamic interactions of molecules between gas and dust(ice) surface. Investigation of such physical and chemical processes is therefore crucial. In this talk, I will introduce some efforts on understanding the chemical diversity especially from the view point of semi-statistical studies. Observations tell us that formation pathways of COMs are not well understood yet even for some fundamental COMs such as CH_3CN, $HCOOCH_3$, and $(CH_3O)_2O$ [e.g. 1]. All these molecules are suggested to be formed via radical reactions on dust/ice surface. Observations of their isotopic species and related radicals are important, although it requires detailed knowledge on their rotation transitions. Some of them are not enough to be used for astronomical observations.

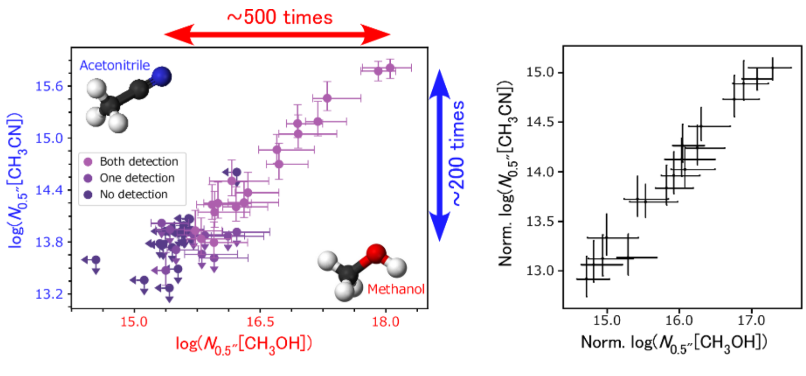

Figure 1: CH_3OH vs CH_3CN abundances observed toward young sources in Perseus.

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