Chemical Models of Hot Molecules at Shocks in Outflows

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It is observationally known that outflows are associated with many young stars, and they are thought to originate from accretion disks around the stars. Meanwhile, molecular line observations have shown that some molecules such as CH_3OH and SiO are very abundant at shocks and/or clumps in outflows.

In this work we have constructed chemical models at shock fronts in outflows by calculating time-dependent gas-phase reactions which are initiated by evaporation of icy mantle molecules on dust grains [1]. We have studied dependences of the chemical structure of O-, N-, and S-bearing molecules at the shocks on different physical conditions to show that a variety of molecular abundance ratios can be obtained, owing to the dependence of dissociation rates on gas temperature and of adsorption rates on dust temperature. Initial condition, that is, physical properties in disks at the upstream of the outflow also affects the abundance ratios. Our results suggest that observations of molecular abundance ratios will trace the physical structure and the chemical processes, especially gas-grain interactions, at shock in outflows.

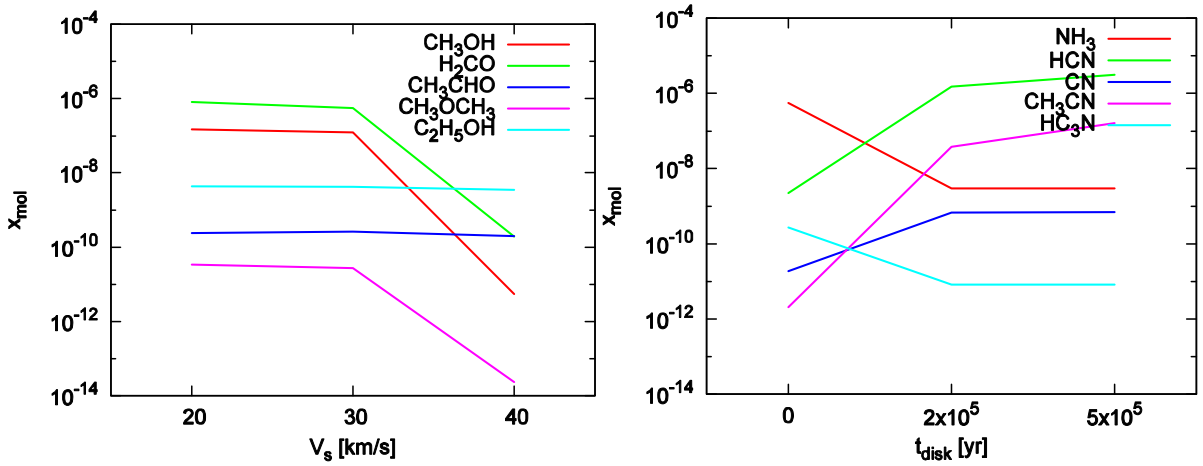

Figure 1: Dependences of the molecular abundances at shock on the shock velocity (the gas temperature) (*left*), and on the time which the molecules spend in the disk after the icy mantle evaporation and before the outflow launching (*right*). Some parent molecules (e.g., CH_3OH, H_2CO) and daughter species (e.g., CH_3OCH_3) are depleted at strong shock (*left*). Some N-bearing daughter species (e.g., HCN, CH_3CN) are abundant if they move into the outflow after they spend enough time in the disk (*right*).

References

[1] H. Nomura & T.J. Millar 2004, A&A, 414, 409