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Condensation with dust/gas separation and chemical fractionation in a protoplanetary disk

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The inner edge of a protoplanetry disk is the region where all the solids are vaporized, where condensation/evaporation plays a critical role in chemical evolution of dynamic disk. We have investigated chemical evolution of dust and gas with a kinetic condensation model (Nagahara and Ozawa, 2008, 2009) and kinetic parameters determined by condensation/evaporation experiments by our group. The model is based on the Hertz-Knudsen equation and mass balance between solid and gas in a cooing gas. Free parameters are cooling time of the system, total pressure and gas/dust separation efficiency, which is tentatively expressed by the critical size of dust separation.

The results show that there are three regimes in terms of chemical fractionation; one is the regime where no chemical fractionation takes place due to very fine grain size of condensing dust, one where no chemical fractionation takes place due to very large dust size, and one where effective fractionation takes place depending on the cooling time scale and critical dust separation size. The cooling rate and critical size for dust separation can be regarded as the relative velocity of gas around the inner edge, thus the dynamics of gas.

We discuss the conditions to achieve chemical fractionation among chondrites.