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TITLE: HDO/H_2O ratios simulated by a multi-stage solar nebula model and conclusions for the formation of comets and parent bodies of chondrites (PBCs)

ABSTRACT BODY:

Abstract Body: The disk from which our solar system originated was formed from a cold cloud core consisting of gas and dust. We simulated the chemical evolution of this core for 1 to 6 Mega years. Its density and temperature, which differ for the gas and dust phase, are influenced by the interstellar radiation field (ISRF). Due to the cold dust (< 15 K) water ice forms on the surface of the grains and reaches a relative abundance w.r.t. H_2 of ~ 10^{-4} in less than 10^6 years. We obtained a high HDO/H_2O ratio between 1 and 10 % which decreases if the ortho-to-para ratio (OPR) of H_2 tends to 1. The gas phase deuteration is lower, especially in the outer core region (0.01- 0.1 %) and strongly depends on the intensity of the ISRF. In addition, it is also influenced by the OPR.

The collapse of the cloud core, simulated by a semi-analytical solution of the magneto-hydrodynamic equations, produces the proto-sun, disk, and outer envelope. Around the proto-sun a hot corino (HC) evolves. The maximum extension of its outer boundary (R_{HC}) and its maximum temperature at 1 AU (T_{HC}) depend on the inflow velocity during the collapse and, hence, on its duration (D_C). For a fairly slow collapse with D_C ~ 617,000 years we find R_{HC} ~ 2.1 AU and T_{HC} ~ 240 K while for a relatively fast collapse (D_C ~ 84,800 years) R_{HC} is nearly 9.3 AU and T_{HC} reaches 1280 K. In the HC of the fast collapse, the water desorbed from the dust with a relatively high HDO/H_2O ratio is mixed with low deuterated water formed by hot neutral reactions (HNRs) in the gas phase. The resulting HDO/H_2O ratio varies between 10^{-5} and less than 10^{-3}. In the HC of the slow collapse, HNRs occur only near the inner HC boundary (~ 0.03 AU). Consequently, the gas phase HDO/H_2O ratios in the outer HC region vary between 10^{-3} and 10^{-2}.

Based on the obtained HDO/H_2O ratios, we draw conclusions for the formation region and time of comets and PBCs as well as for the intensity of the ISRF and the OPR of H_2. Finally, we consider the influence of vertical and radial mixing occurring for the gas and dust in the proto-solar disk.

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