

Hydrogen/deuterium exchanges in interstellar ice analogs

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Star-forming regions in the interstellar medium or small bodies in planetary systems are both known for the presence of extreme deuterium enrichment. Deuterium fractionation is mainly due to zero point energy effects in these cold environments. Nevertheless, this single process is insufficient to reproduce observations like the enrichment disparities between functional groups and other chemical mechanisms have to be considered. The hydrogen-deuterium spontaneous exchanges between water and organic molecules are studied experimentally. The aim is to provide a quantitative description of this process and to derive the corresponding rate constants for (solid-phase) astrochemical networks. Thin films of water ice mixed with a few percent of deuterated organic molecules (methylamine (CD_3ND_2) or methanol (CD_3OD)) are condensed at low temperature ($< 40\text{K}$) and warmed up to 140K . The chemical evolution of the film is then followed by Fourier transformed infrared spectroscopy (FTIR), as in Ratajczak et al. [1]. Our work shows that rapid H-D exchanges occur in the ice during the crystallization process, specifically between the amine or alcohol functional groups and water. The H-D exchanges between water and methylamine are found to obey a second-order kinetics. The temperature dependence follows an Arrhenius law with an activation energy of $\sim 4000\text{K}$.

[1] A. Ratajczak et al., *Astronomy & Astrophysics*, 496, L21-L24 (2009)