Diffusion in Amorphous Solid Water Ice : implications in the interstellar ice chemistry

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To explain the observed molecular abundancies in the interstellar medium, we need the kinetic parameters of relevant reactions in the gas and solid phases and a formalism for the relevant dynamical processes. In the ice mantle of the interstellar grains, essentially composed of water, the bulk reactivity is limited by the diffusion of the molecules wich have to migrate to encounter each other. In order to derive a formalism to combine reactivity and diffusion in models of interstellar ices, we first need to perform an extensive experimental study on both processes.

We concentrate on the formation of the ion OCN^- trough the reaction HNCO + $NH_3 \rightarrow OCN^-NH_4^+$. This ion has been observed in solid phase with various abundances in protostar infrared spectra but it is missing in the spectra of starless molecular clouds [1]. This reaction has the advantage to exhibit a low activation barrier so that it may be distinguishable from the slower diffusion process [2] [3].

First, we performe a kinetic study of the solid-phase thermal reaction HNCO + NH_3 $\rightarrow OCN^-NH_4^+$ in a water-free HNCO:NH_3 ice mixture. The ice is formed by growing a film on a cold surface, brought to a fixed temperature between 8 K and 60 K and monitored by Fourier Transform Infrared Spectroscopy.

Then we characterize the diffusion of HNCO, NH_3, H_2CO and CO in amorphous solid water ice. The ice is formed on a cold surface by deposing a mixture of H_2O and one of the selected molecules. The temperature is raised to allow the molecule to diffuse and desorb. The diffusion coefficients are extracted from the decreasing abundance of the diffusing molecule.

Finally, we study the kinetic behavior of the HNCO + NH_3 reaction when the two molecules are diluted in amorphous water ice.

References

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