
Laboratory study of thermal and non-thermal desorption processes of interstellar ices

Mathieu Bertin^{*1}, Mikhail Doronin^{1,2}, Xavier Michaut¹, Laurent Philippe¹, Pascal Jeseck¹, Françoise Pauzat², Yves Ellinger², Alexis Markovits², Jean Claude Guillemin³, and Jean-Hugues Fillion¹

¹Laboratoire d'Etude du Rayonnement et de la Matière en Astrophysique (LERMA) – Université Pierre et Marie Curie [UPMC] - Paris VI, Observatoire de Paris, Université de Cergy Pontoise, Université Pierre et Marie Curie (UPMC) - Paris VI, INSU, CNRS : UMR8112, École normale supérieure [ENS] - Paris – 61, avenue de l'Observatoire - 75014 PARIS, France

²Laboratoire de chimie théorique (LCT) – CNRS : UMR7616, Université Pierre et Marie Curie (UPMC) - Paris VI, Université Pierre et Marie Curie [UPMC] - Paris VI – Tour 12-13, 4ème étage, 4 place Jussieu, Case Courrier 137, 75252 PARIS, France

³Equipe Chimie Organique et Supramoléculaire Sciences Chimiques de Rennes – Ecole Nationale Supérieure de Chimie de Rennes – France

Résumé

In cold regions of the Interstellar Medium (ISM), like star-forming regions or protoplanetary disks, molecules form or accrete on the surface of dust grains. The resulting icy mantles represent the main reservoir of molecules beside H₂. Through desorption processes, these ices can eventually enrich the gas phase with more or less complex species, and therefore influence observed gas phase abundance ratio and chemistry. In the vicinity of warm objects (protostar, edge of clouds...) thermal energy is high enough to trigger sublimation of the ices. This is not the case in the colder regions, but other mechanisms, such as cosmic-rays or UV photons impact on the ices, can stand at the origin of the ice desorption. In any case, both thermal and non-thermal desorption processes need to be quantified in order to get a better understanding of the observed molecular abundance ratio, and to bring trustable and relevant parameters for astrochemical models.

The efficiency of thermal desorption is usually linked to the strength of the interaction energy between the adsorbed molecule and the ice surface, so-called adsorption energy. Despite its interest, only few quantitative studies have been performed to measure this energy for astrochemistry-relevant molecules and/or ices, and discrepancies in the experimental methods lead usually in difficult intercomparisons between the values obtained from different studies. We propose a systematic method, based on a joint experimental-theoretical approach, to measure adsorption energies of molecules on model surfaces (water ices, carbonaceous and silicate substrates), with the aim to ultimately establish adsorption energy database for a large collection of molecules. The method has already been applied to rare gas atom adsorption, as well as on organics adsorption such as methanol and acetonitrile/isoacetonitrile.

Less is known concerning non-thermal desorption processes. Using energy-resolved studies at the synchrotron SOLEIL, we have focused our studies on UV photodesorption in the 7 - 13.6 eV range. Photodesorption of simple molecules (CO, H₂O...) have already been studied

*Intervenant

using broad band lamps. In our case, the energy resolution allows us for extracting (i) absolute photodesorption rates as a function of the photon energy, applicable to any different UV field, and for (ii) identifying the molecular mechanism and the parameters involved in the desorption process. I will summarize results we have obtained in the case of simple molecular ices such as CO, N₂ and CO₂ and show the crucial role played by the surrounding molecules (ice composition) and the photochemistry in the UV photodesorption. Finally, I will present very recent results obtained on the photodesorption of CH₃OH and H₂CO, pure and mixed in CO-rich ices.