FORMATION OF MOLECULES ON ANALOGUES OF DUST GRAINS AND AEROSOL PARTICLES
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It is well known that there are key molecules, which are important in the chemical evolution of space and planetary atmosphere environments, for which gas-phase reactions are unsuited to explain the observed abundances. Theoretical work has suggested that formation of certain molecules, most importantly molecular hydrogen, should occur efficiently on solid particles, such as dust grains in the interstellar medium or aerosol ("haze") particles in the atmosphere of solar system bodies such as Titan. Using surface science and atomic/molecular beam techniques, in the last ten years we investigated the formation of molecular hydrogen and other molecules on different types of dust analogues in simulated space environments. More recently, we used our technique to study the formation of molecules on aerosol particles ("tholins") that are analogues of the haze particles suspended in Titan’s atmosphere. In concert with our experimental work, we developed theoretical tools to analyze the experimental results and use them to make predictions on the formation of molecules in actual space environments.

The experiments consist in irradiating a solid surface (such as of ices, amorphous carbon, amorphous silicates, or tholins) with neutral atoms. In the formation of molecular hydrogen, we used atomic beams of hydrogen and deuterium with a high degree of dissociation (Pirronello et al., 1997). Or, in the oxidation of CO, we used a beam of oxygen atoms. A mass discriminating detector measures the reaction products that are formed on and come out from the solid surface during the irradiation phase. If molecules do not form during the irradiation phase because of the limited mobility of the atoms or radicals on the surface, or if they form but are not ejected from the surface, we then proceed with a thermal programmed desorption (TPD) in which the temperature of the surface is ramped and molecules form and come off. By studying the pattern of the products coming off in different conditions, information on the kinetics and dynamics of the reactions can be obtained (for more details, see: Vidali et al, 2004).

Finally, using coupled rate equations, physical parameters can be extracted from the experimental data, and the molecule formation rate in steady state conditions and in appropriate space environments can be obtained (Katz et al., 1999; Perets et al., 2007).

This coupled experimental and theoretical program that has been very successful in quantitative prediction of the formation of molecular hydrogen in interstellar environments is being applied to the study of the formation of molecules on aerosol particles in planetary atmospheres (i.e., Titan’s). A description of the methods and first results will be given in the presentation.

Figure 1: Calculated recombination efficiency of hydrogen at steady state on amorphous silicate (solid line) and polycrystalline silicate (dashed line) vs. temperature, using the parameters obtained from the TPD experiments. From Perets et al., 2007.
References


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