

FORMATION OF WATER ON SILICATE SURFACES UNDER INTERSTELLAR CONDITIONS

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Abstract. We explore experimentally the formation of water molecules from O₂ and D atoms on bare grains composed of amorphous silicates analogous to those in diffuse interstellar clouds. We provide the fractions of D₂O and D₂O₂ molecules formed on the silicate surface held at 10 K from the O₂ + D pathway using RAIRS and TPD techniques. For comparison, we also study the formation of water molecules on surfaces covered with amorphous water ice representing the dense clouds.

Solid water ice is a very abundant astrophysical material. It is believed to be the most abundant condensed component in the universe and particularly in dense molecular clouds. It is also the most abundant species in icy mantles. Water ice is likely to form directly on the surface of dust grains through H atom addition reactions. Three different hydrogenation channels have been proposed for water formation (Tielens & Hagen 1982) where dust grains play a role of catalyst: O + H (Dulieu *et al.* 2010; Jing *et al.* 2011), O₂ + H (Miyachi *et al.* 2008; Ioppolo *et al.* 2008) and O₃ + H (Mokrane *et al.* 2009).

The process of water formation from O₂ + H and O₂ + D pathways follows these reactions:



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Our experiments were performed using the FORMOLISM (FORmation of MOLEcules in the ISM) setup, which consists of an ultra-high vacuum (UHV) stainless steel chamber with a base pressure lower than 1×10^{-10} mbar.

In the experiments a silicate sample held at 10 K is exposed to O_2 molecules, and the oxygen ice film (~ 1 ML) is irradiated with D atoms for several exposure times at the same surface temperature. Both RAIRS and TPD results showed the formation of D_2O and D_2O_2 molecules as well as D_2 molecules. The fraction of D_2O molecules formed on the cold silicate sample when all the O_2 molecules leave the surface is about (18%) and that of D_2O_2 molecules is ($\sim 23\%$).

It is probable that most of the D_2O molecules formed on the surface desorb into the gas phase upon formation. Their fraction is ($\sim 82\%$) of the total D_2O molecules expected to be formed from the $O_2 + D$ reaction. This high fraction of water molecules released into the gas phase from bare silicates upon formation is probably due to the low binding energy of the final products such as OD and D_2O molecules (Cazaux *et al.* 2010).

Our experiments show that substrates and experimental conditions have a large influence on the final products (Chaabouni *et al.* 2012). However, previous results of Miyauchi *et al.* (2008) and Ioppolo *et al.* (2008) showed that water molecules are the major product of formation in the $O_2 + D$ experiments, at least for the monolayer or the sub-monolayer regime.

In a future study we will compare surfaces and will investigate different substrates for the formation of water molecules.

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