

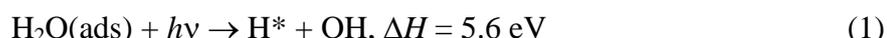
Hydrogen atom desorption from water ice by 157 nm irradiation at 8-130 K

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Interstellar grains typically consist of silicates or carbonaceous cores and are covered predominantly by water ice. In a diffuse cloud, the ice mantle is subjected to vacuum-ultraviolet (VUV) irradiation [1]. Photodissociation of H₂O molecules yielding H + OH fragments is the major channel in the gas phase photolysis for 105–185 nm. The excess energy over and above that required to break the HO–H bond appears predominantly as product translation:



where H* represents a highly translationally excited H photoproduct with a few eV. Energetic hydrogen atoms could drive chemical reactions that are endothermic, or possess activation energy barriers.

In an ultrahigh vacuum chamber, amorphous solid water (ASW) and polycrystalline ice (PCI) films were prepared on a cooled platinum substrate [2]. A water ice film was photodissociated at 157 nm with a pulsed laser. Resonance-enhanced multiphoton ionization was used to probe H atom photofragments. Translational energy distributions of H atoms were obtained by analyzing the time-of-flight (TOF) mass spectra of H atoms.

TOF spectra of H atoms from photodissociation of ASW and PCI ice films were measured at 8 K. Both of them could be characterized by a combination of three (fast(A, $T_{\text{trans}} = 4750 \text{ K}$), medium(B, $T_{\text{trans}} = 625 \text{ K}$), and slow(C, $T_{\text{trans}} = 100 \text{ K}$) different Maxwell-Boltzmann energy distributions. Each TOF spectrum consists of the same three components, but contributions of each component are different.

TOF spectra were measured in the range of 8-130 K. The average translational temperatures of the component (A) and (B) didn't change, but that of the component C increased with substrate temperatures above 90 K. Integrated H signal intensities of the component (A) and (B) were nearly constant in the range of 8-70 K. Molecular dynamics simulation shows the H atom photodesorption probability in the top four monolayers does not depend on ice temperature at 10, 20, 30 and 90 K [3]. These results imply that the component (A), (B) and (C) come from the topmost H₂O layer, some layers just below the topmost H₂O layer and the deeper monolayers, respectively (Fig. 1).

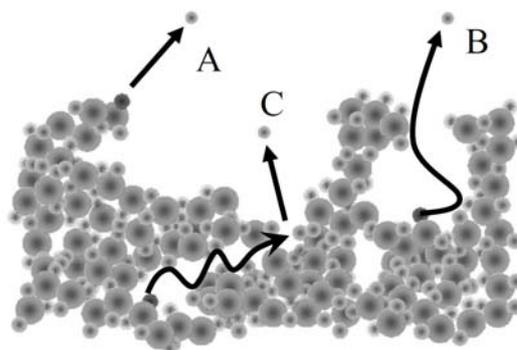


Fig. 1 Desorption mechanisms for hydrogen atoms from photodissociation of water ice

References

- [1] A. Yabushita, T. Hama, & M. Kawasaki, 2013, *J. Photochem. Photobiol. C*, 16, 46
- [2] A. Yabushita, D. Kanda, N. Kawanaka, M. Kawasaki, M. N. R. Ashfold, 2010, *J. Chem. Phys.* 125, 133406
- [3] C. Arasa, S. Andersson, H. M. Cuppen, E. F. van Dishoeck, & G.-J. Kroes, 2010, *J. Chem. Phys.* 132, 184510