HYDROXYL RADICALS IN SILICATES INDUCED BY PROTON IRRADIATION

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Introduction: In order to study the possibility to form hydroxyl radicals in silicates in astrophysical environments, we have irradiated thin amorphous silicate films with protons at energies and fluences compatible with those expected in the Interstellar Medium (ISM). We investigated and probed by infrared (IR) spectroscopy the OH band, before and after irradiation to estimate the H^+ irradiation effect on the evolution of this band. NanoSIMS profiling analyses of H in the samples have also been conducted at MNHN.

Experimental conditions: Thin silicate amorphous films, typically 100 nm thick, have been synthesized as described in [1-3]. San Carlos Mg-rich composition olivine, analogous to the crystalline silicate dust formed around the evolved stars and injected into the ISM, has been used as precursor. The geometrical characteristics of the samples are in good agreement with the high surface to volume ratio of the interstellar dust. H^+ irradiations at energies of 3.5, 2.5 and 1.5 keV have been performed in order to implant the ions at different depths in the samples. Fluences of 3×10^{16}, 10^{17} and 3×10^{17} atm/cm^2, are used to evaluate the effect of the irradiation dose on the formation of the OH bonds.

Analytical tools: IR spectroscopy has been used to investigate the OH band in the region of 3500 cm^{-1}. In addition, NanoSIMS measurements have been performed to determine the D/H ratio in the sample. This is important to evaluate the part of hydrogen atoms in the samples due to possible atmospheric contamination from the ones resulting from the proton implantation and reaction.

Results and Conclusion: After a previous study using He^+ irradiation [4] and leading to the amorphization of the silicates resulting to IR signatures compatible with those observed in the ISM [5], we now use the reactive ions H^+ in order to study the possibility to form new bonds in the samples. We investigate in particular the OH and/or SiH bonds.

The IR signature of the OH band in our samples has been clearly enhanced with increasing fluence. This has been a first indicator of the success of the experiment. We estimate that the OH column density has increased by a factor of ~ 2 after an irradiation with a fluence of 3×10^{17} atm/cm^2. We show the possibility to form OH bonds but failed to detect SiH bonds in our irradiated samples.

Quantitative depth profiling for hydrogen in our samples has been done with the NanoSIMS. The obtained results show that around 2% of the incident ions have formed OH bonds in the sample. The other implanted ions were probably lost by diffusion as H_2 molecules and escaped the samples.

Our experiment clearly shows that it is possible to form OH bonds in silicates irradiated at energies and fluences expected in the ISM. The silicates could thus be reservoirs of water that could play a key role later, during the accretion period in the inner disk.

References: [1] Z. Djouadi at al. 2005, *Astronomy & Astrophysics*, 440, 179-184, [2] C. Davoisne et al. 2006, *Astronomy & Astrophysics*, 448, L1. [3] Z. Djouadi et al. 2007, *Astronomy & Astrophysics*, 468, L9. [4] K. Demyk et al. 2001, *Astronomy & Astrophysics*, 368, L38. [5] Kemper et al., 2004, *The Astrophysical Journal*, 609, 826.