Shielding of amino acids in water ice

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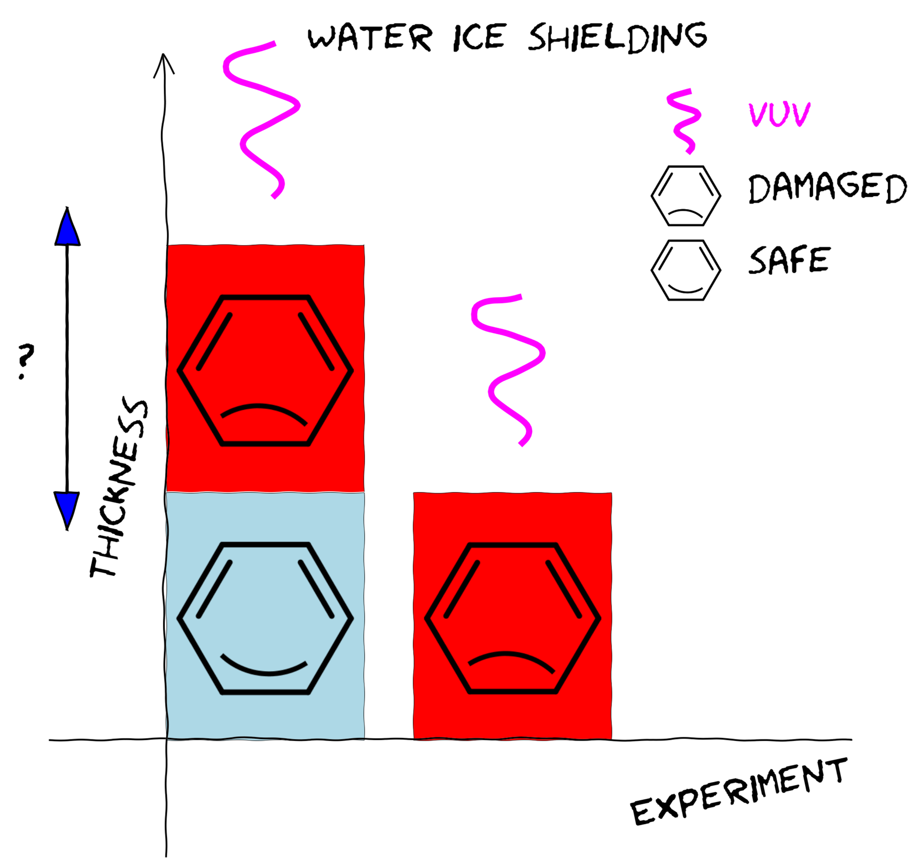
Introduction

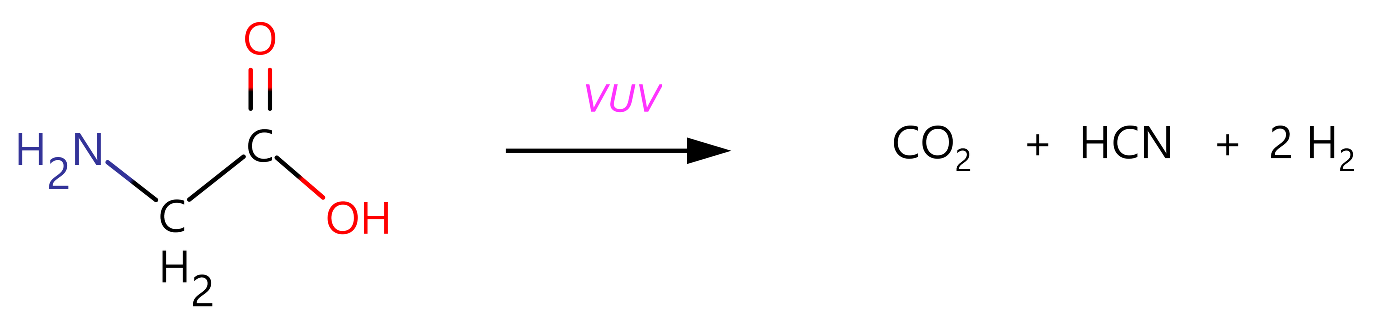
Comets contain organic molecules, including amino acids[1,2]. This implies that photo-chemically instable molecules need to survive for millions of years in the strong radiation fields of space. Here we investigate how much water ice is needed to provide enough protection from vacuum ultraviolet (VUV) radiation to protect glycine (Gly) in relevant cometary environments, as well as other bodies in the Solar System, like icy moons such as Europa. This laboratory study[3] is directly linked to the recent detection of glycine on comet 67P [2].

How much water ice is required to shield the embedded molecules from VUV radiation?

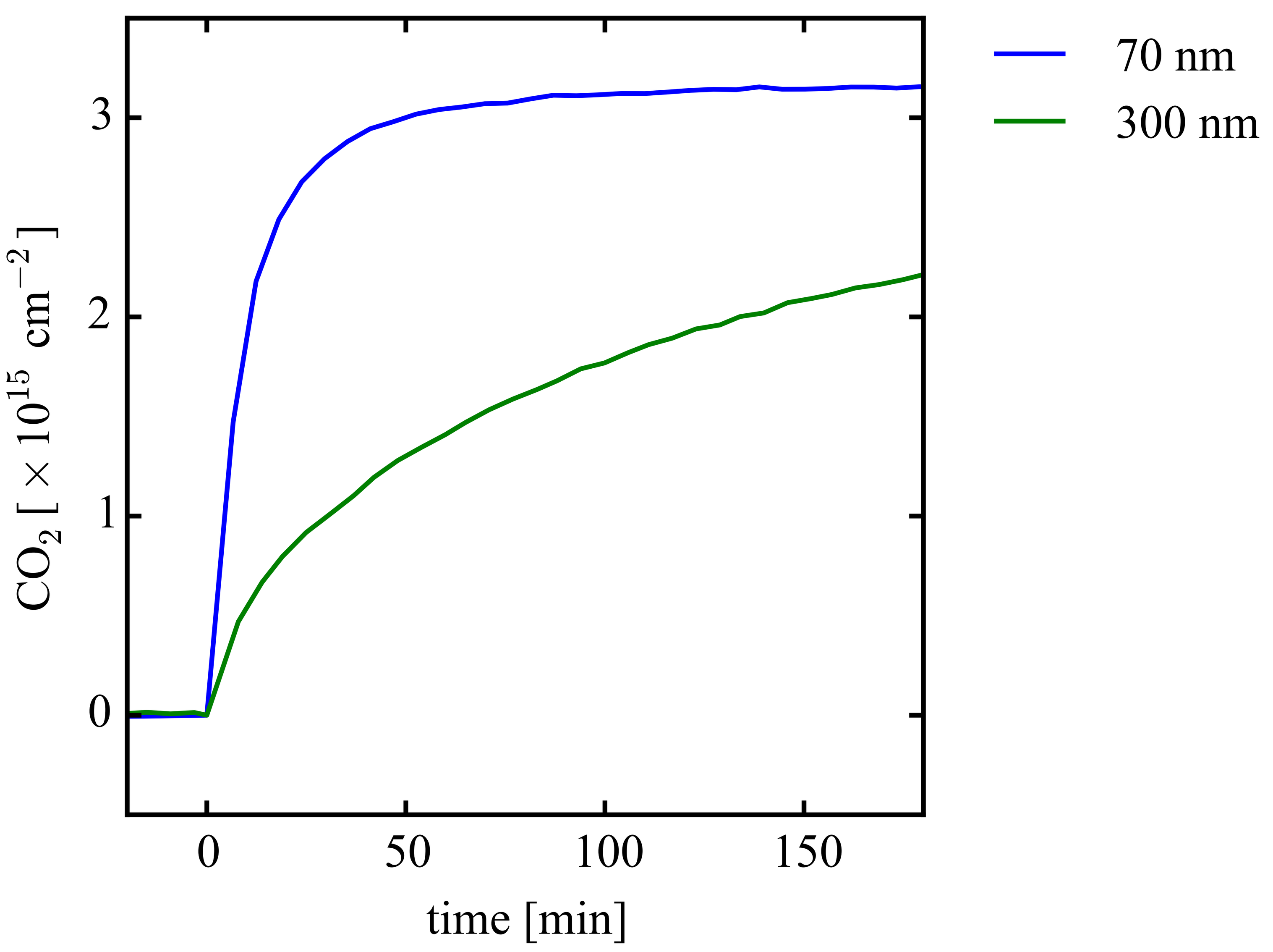


Experiments and Results

H_2O and Gly are simultaneously deposited on a 10 K sample, and then irradiated with VUV radiation. CO_2 is formed as a reaction product and its abundance measured using *in situ* infrared spectroscopy[3].



Shown below is the formation of CO_2 in two H_2O:Gly experiments as a function of time. Both contain the same amount of Gly, but the amount of water is different.



The half-life of Gly in water is determined from the formation of CO_2 in the two experiments: **8 min in the 70 nm** experiment and **68 min in the 300 nm** experiment.
Radiation shielding is expressed in the thickness required to decrease the flux by half. Our show the flux has decreased by a factor of 8, indicating roughly **75 nm water decreases the VUV flux by half**.

Astronomical Implications

From the half-life time of Gly and the half-value thickness of water, we can estimate the stability of Gly in thicker water layers. We expressed this as the required water layer to survive 1 million years in different locations in space, as shownin the table below[4].

Environment	VUV flux [ph $s^{-1}cm^{-2}$]	Half-life Gly [min]	Shielding 1 Myr [nm]
Laboratory setup	1.7×10^{15}	8	2.7×10^{3}
Earth, 1 AU	1.2×10^{12}	1.1×10^{4}	2.0×10^{3}
Jupiter, 5.2 AU	4.5×10^{10}	3.0×10^{5}	1.7×10^{3}
Kuiper belt, 43 AU	6.5×10^{8}	2.1×10^{7}	1.3×10^{3}
Oort cloud, 50.000 AU	5.0×10^{4}	2.7×10^{11}	4.4×10^{2}
Interstellar medium	1.0×10^{8}	1.4×10^{8}	1.1×10^{3}
Dense Cloud	1.0×10^{3}	1.4×10^{13}	77

Conclusions

- Even thin ice layers are sufficient to protect Gly from VUV radiation in water ices.
- Ices found at different locations in the Solar System provide enough shielding for Gly to survive Solar VUV radiation.

[1.] Goesmann et al., Sci., Vol. 349, 6247, 2015 [2.] Altwegg, Sci. Adv. Vol. 2, 5, 2016 [3.] Kofman et al., in prep [4.] Ehrenfreund ApJ, Vol. 550, 1, 2001