The Role of Solid Phase in the Radiation Astrochemistry of Ices

Mifsud, D.V.,[1,2]* Hailey, P.A.,[1] Herczku, P.,[2] Kovács, S.T.S.,[2] Sulik, B.,[2] Juhász, Z.,[2] Kaňuchová, Z.,[3] Ioppolo, S.,[4] Paripás, B.,[5] McCullough, R.W.,[6] and Mason, N.J.[1]
*presenter
[1] duncanvmifsud@gmail.com, University of Kent, United Kingdom
[2] Institute for Nuclear Research (Atomki), Hungary
[3] Slovak Academy of Sciences, Slovakia
[4] Queen Mary University of London, United Kingdom
[5] University of Miskolc, Hungary
[6] Queen's University Belfast, United Kingdom

We have examined whether the solid phase of an irradiated astrochemical ice analogue plays any role in the physico-chemical evolution of the ice. Systematic studies have thus far largely focused upon the role of temperature in the radiation physics and chemistry of such ices.[1,2] However, astrochemical ices are known to undergo cycles of thermally-induced crystallization and radiation-induced amorphization, thus motivating our research interest. The 2 keV electron irradiation of the amorphous and crystalline phases of a series of ices, including CH_3OH and N_2O, revealed that the decay rates of these ices are dependent upon the strength and extent of the intermolecular bonding network within the solid phase; with crystalline ices being more radio-resistant than amorphous ones.[3,4] In the case of CH_3OH, the decay of the amorphous phase is significantly more rapid than that of the crystalline phase due to the strong and extensive hydrogen-bonding network present in the latter. Conversely, the decay of amorphous N_2O is only slightly more rapid than that of the crystalline one, since the molecular dipole interaction is only a weakly attractive potential.

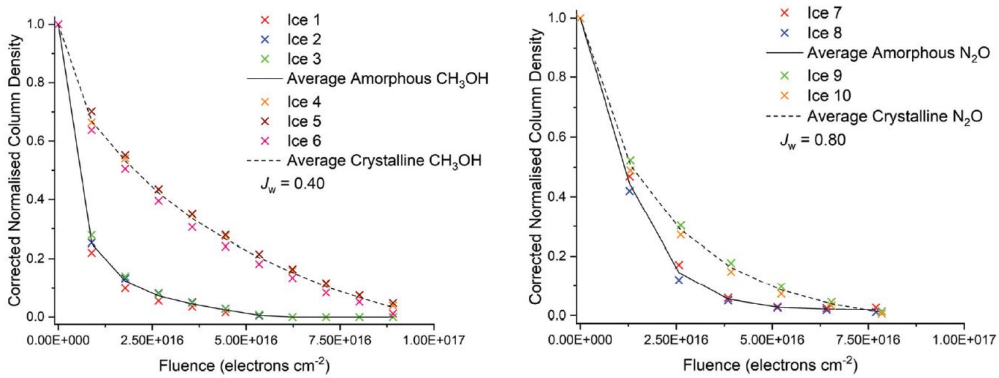

Figure: 2 keV electron-induced decay rates for the amorphous and crystalline solid phases of CH3OH (*left*) and N2O (*right*) astrophysical ice analogues at 20 K.

[1] Mifsud, D.V.; Kaňuchová, Z.; Ioppolo, S.; *et al.* Mid-IR and VUV spectroscopic characterization of the thermally processed and electron irradiated CO_2 astrophysical ice analogues. *J. Mol. Spectrosc.* **2022**, *385*, 111599.
[2] Sivaraman, B.; Jamieson, C.S.; Mason, N.J.; Kaiser, R.I. Temperature-dependent formation of ozone in sold oxygen by 5 keV electron irradiation and implications for Solar System ices. *Astrophys. J.* **2007**, *669*, 1414.
[3] Mifsud, D.V.; Hailey, P.A.; Herczku, P.; *et al.* Comparative electron irradiation of amorphous and crystalline astrophysical ice analogues. *Phys. Chem. Chem. Phys.* **2022**, *24*, 10974.
[4] Mifsud, D.V.; Hailey, P.A.; Herczku, P.; *et al.* Laboratory experiments on the radiation astrochemistry of water ice phases. *Eur. Phys. J. D* **2022**, *76*, 87.