From Interstellar Ices to Polycyclic Aromatic Hydrocarbons
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Photoinduced Radical Reactions on Astrochemical Ice Analogs

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Surfaces are known to be important in producing molecules that are observed in interstellar space. In the cold interstellar medium (ISM) these surfaces are in the form of ices composed primarily of water. Laboratory studies on ice analogs at low temperatures have shown solid phase reactions can produce a myriad of molecules; from simple diatomics to complex organics e.g. Milligan and Jacox (1971), Bennett and Kaiser (2007), Oba *et. al.* (2010). However, there have been few experiments that have addressed reactions occurring directly between gas phase molecules and solid ice surfaces. Lyman alpha photons (Lyα, 10.2eV) are able to break bonds in the ice forming highly reactive radical species. We have shown that these radicals are able to sequester gas phase molecules to efficiently produce species that remain on the ice.

Recently, we have shown that water ice, irradiated with Lyα radiation, reacts efficiently with CO(g) forming CO_2 ice (Yuan, Cooke and Yates 2014). In the ISM, the abundance of CO_2(ice) greatly exceeds that in the gas phase, indicating that solid phase processes are likely involved (van Dishoeck *et. al.* 1996, Ioppolo *et. al.* 2011, Noble *et. al.* 2011). We observe a direct reaction (Eley-Rideal) between CO in the gas and Lyα produced OH radicals that provides a new mechanism to produce CO_2(ice). Preliminary studies have indicated that OH radicals are able to sequester other astrochemically important molecules from the gas phase and react with other species in the ice. Currently, we are studying reactions of photolysed water ice with neutral gas phase O_2, as well as surface radical reactions with alkanes to produce more complex organic species. These radical reactions have not been well studied and will be important in astrochemical models that predict the abundances of molecules in ices and in the gas.

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