The shock synthesis of complex organics from impacts into cometary analogue mixtures

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Introduction: If amino acids are required for the evolution of life, what was their source? Many different theories abound as to the source of amino acids on the early Earth including exogenous delivery from comets/asteroids (for example, glycine was found recently on comet Wild-2 [1]), formation in the protoplanetary nebula [2], or UV catalysed reactions of gases [3]. An alternative explanation is that amino acids can be shock-synthesised during the impact on an icy body onto a rocky body (or, equivalently, the impact of rocky body onto an icy surface). This theory is supported by computer simulations [4] and by very recent experimental data, which demonstrated the formation of simple (including abiotic) amino acids from shocks into ice mixtures mimicking the composition of comets and the surfaces of the icy Jovian and Saturnian satellites. Although the results from these experiments are fundamentally important, the yield of synthesised amino acids was low (nano-grams of material), complicating their detection and identification. In order to increase the collected yield of complex organics, and aid in their detection and identification, we have implemented a new collection technique within our hypervelocity impact facility.

Experimental Methodology: Figure 1A) shows a low-resolution high-speed photograph of an impact plasma generated from an impact of a stainless-steel sphere into a mixture of water, CO_2, ammonia, and methanol ices. The plasma has an intense blue colour, and lasted for < 1 msec (the frame-rate of the camera). It is during and within this flash that complex organics are most likely synthesised, and thus to maximise the collection of these materials, we have implemented a new collection mechanism. Figure 1B) shows the prototype collection mechanism. Here an aluminium cold-plate ($\sim$150 K) is placed in front of the target holder containing the ice mixtures. The plate has a central hole which allows the projectile to pass through to impact the ice mix. The plate also has two brass holders (Fig. 1C) which contain 10-mm diameter discs of high purity, sterilised gold foil (also at low temperature). During the impact, the plasma will condense onto the cold surfaces of the gold foil. One of the gold foils is pointed directly at the ice mixture, the other is pointed backwards into the gun's target chamber (and thus acts as a control). The gold discs can then be removed (Fig. 1D) and mounted onto stubs for analyses using Raman spectroscopy, SEM-EDX, GC-MS as required.

Preliminary Results Several trial shots have been performed using this system and residues have been found. The initial analysis of these residues is now underway and the results will be presented at the conference. If successful, this collection and analysis methodology will greatly speed up the number of experiments that can be done, allowing us to explore a large parameter space and determine the efficiency of shock syntheses of complex organics as a function of impact speed (peak shock pressure) and target composition.

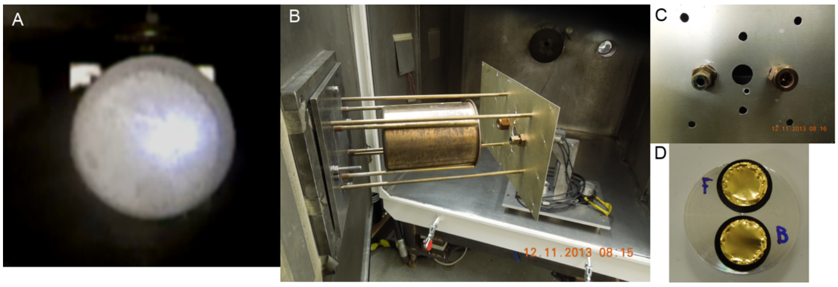

Figure 1: (A) Impact plasma caused by a hypervelocity impact into a cometary analogue ice mixture; (B) container and condensing system in place in the light gas gun; (C) brass holders containing high-purity gold disks; (D) The gold discs removed from the holders ready for subsequent analyses.

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